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THE
CROUNIAN Lectures
ON
MUSCULAR MOTION.

For the Years MDCCXLIV and MDCCXLV.

Read before the
ROYAL SOCIETY:

By JAMES PARSONS, M. D. and *Fellow*
of the ROYAL SOCIETY.

Being a SUPPLEMENT to the *Philosophical*
Transactions for those Years.

*Mundi Pars est Aer, & quidem necessaria: hic est enim qui Cælum
Terramque connectit.*

SENEC. Nat. Qu. l. 2. c. 4.

*Animantes autem adspiratione aeris sustinentur. Ipse enim Aer
nobiscum videt, nobiscum audit, nobiscum sonat; nihil enim sine eo
feri potest.*

CIC. de Nat. Deor. l. 2. c. 33.

L O N D O N:

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P R E F A C E.

I.

AS the following Sheets were composed rather by Injunction and Duty than Choice, it is hoped their Imperfections may claim some Indulgence from the Reader; since such Freedom can scarce be exhibited in the Prosecution of a Subject so difficult and confined, as might be expected, if it were more agreeable to the Author, or less limited and particular in its Nature.

‘ However, I flatter myself that something New will be found in what I offer as my own; which, perhaps, is capable of being further improved hereafter, towards the Explanation of the Manner in which Muscular Motion is performed.

II.

The Air is a principal Agent of Motion thro' all Nature, and may be called the Spring of all moveable Bodies. No Animal can move on the Earth, in the Atmosphere, or Waters, without its kindly Assistance; nor can there be any Growth of either Animal or Vegetable Bodies, unless promoted by this most useful Element: In short the Phænomena in Nature are numberless, that necessarily require its Aid. In this Light, I find it highly concerned in the Actions of Animals; which, I think, will clearly appear by the Use I make of it in accounting for those of their Muscles: And I find, that without supposing it so, no probable Conjectures can be produced towards accounting for that Motion, which a Review of the several Opinions of the Authors mentioned in my first Lecture will sufficiently testify.

III.

What the Soul is, or in what Manner she makes her Impulse on those Parts of Animals
that

that are the immediate Instruments of Motion, we dare not attempt to guess ; these being wrapp'd up among those Secrets only known to HIM that order'd all Things : But, as the Bodies of Animals are mechanical, and therefore naturally fall within the Sphere of our Understanding, we may make some Attempts towards explaining the several Phænomena that belong to it ; and therefore we can only consider how its Organs are actuated, and not what is the Cause of their Motion ; and must take it for granted, that the Soul makes her Impulse on the Organs, and then endeavour to shew the Nature of the several Consequences of that Impulse, as far as it relates to the Motion of the Muscles.

IV.

And this is carried on, as the Reader will find, upon a Plan and Foundation not merely conjectural, as is the Case of most Writers on this Subject, but (1.) upon the Knowledge of the Structure of a muscular Fibre ; (2.) upon a due Consideration

sideration of the Use of the Interstitial Air, and its Counter-action with that contain'd in the nervous and muscular System; and (3) upon my Observation of the Circulation of the Blood, in the minute Vessels of several Animals, and their parallel Direction to other Fibres: All which Particulars are my own Discoveries; and, being duly connected, seem to me the most likely, that have hitherto appeared, to give some Light into the Nature of Muscular Motion.

V.

These Things naturally lead me to consider the animal Body as a Machine consisting of Two complete Sets or Systems of Organs, each perfect in itself, and each containing a Fluid peculiar to itself, and different from the other. The first of these is that of the Lacteals, Blood-vessels, and Lymphatics, continued to each other, and containing its proper Fluid, the Mass of Blood, and its derivative Juices; and the other is the Nervous and Muscular System,
which

which are also continued to each other, and having their proper Fluid the elastic Aura or Air; which are more fully explain'd and connected in my second Lecture, together with an Account of Two Kinds of Æquilibria proper to Muscles, deducible from these Systems.

VI.

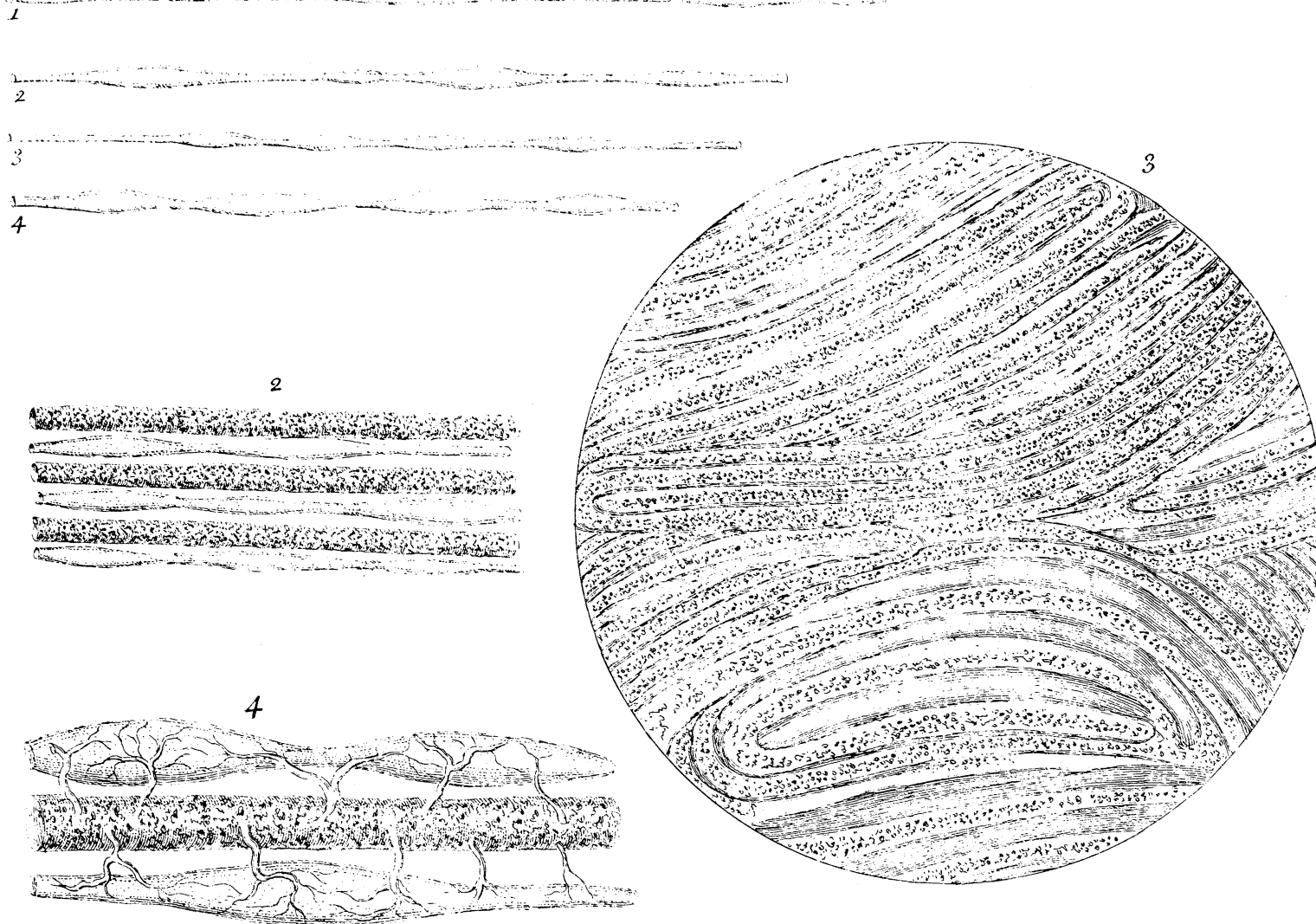
*I have endeavoured, as much as possible, to be brief in my Explanation throughout the Whole; avoiding every Digression that might in the least interrupt the Chain of my Reasoning: And as I have made some Objections to the several Opinions in my first Lecture, which I think they seem'd liable to (in order the better to arrive at the Truth, yet, with all possible Regard to their Characters and Learning), the World is welcome to use me with the same Freedom; and indeed I shall be always glad, if any Improvement arises from such Objections to my Sentiment as the Judicious may justly make;
desiring*

desiring no more at their Hands, than the same Candour, in their Inquiry into mine, that I have shew'd in my Examination of the Opinions of others.

THE

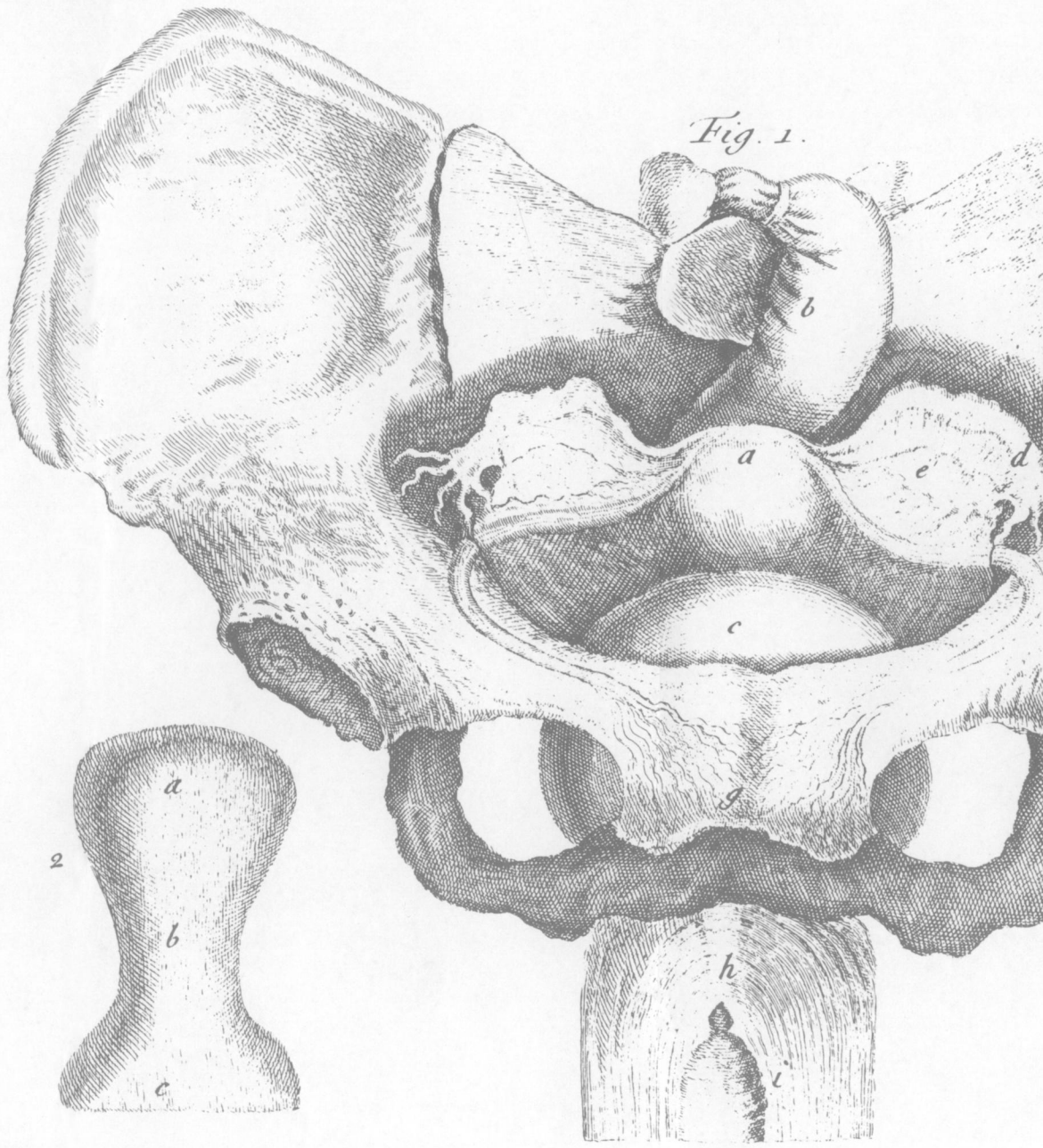
Fig. 1.

TAB. I.



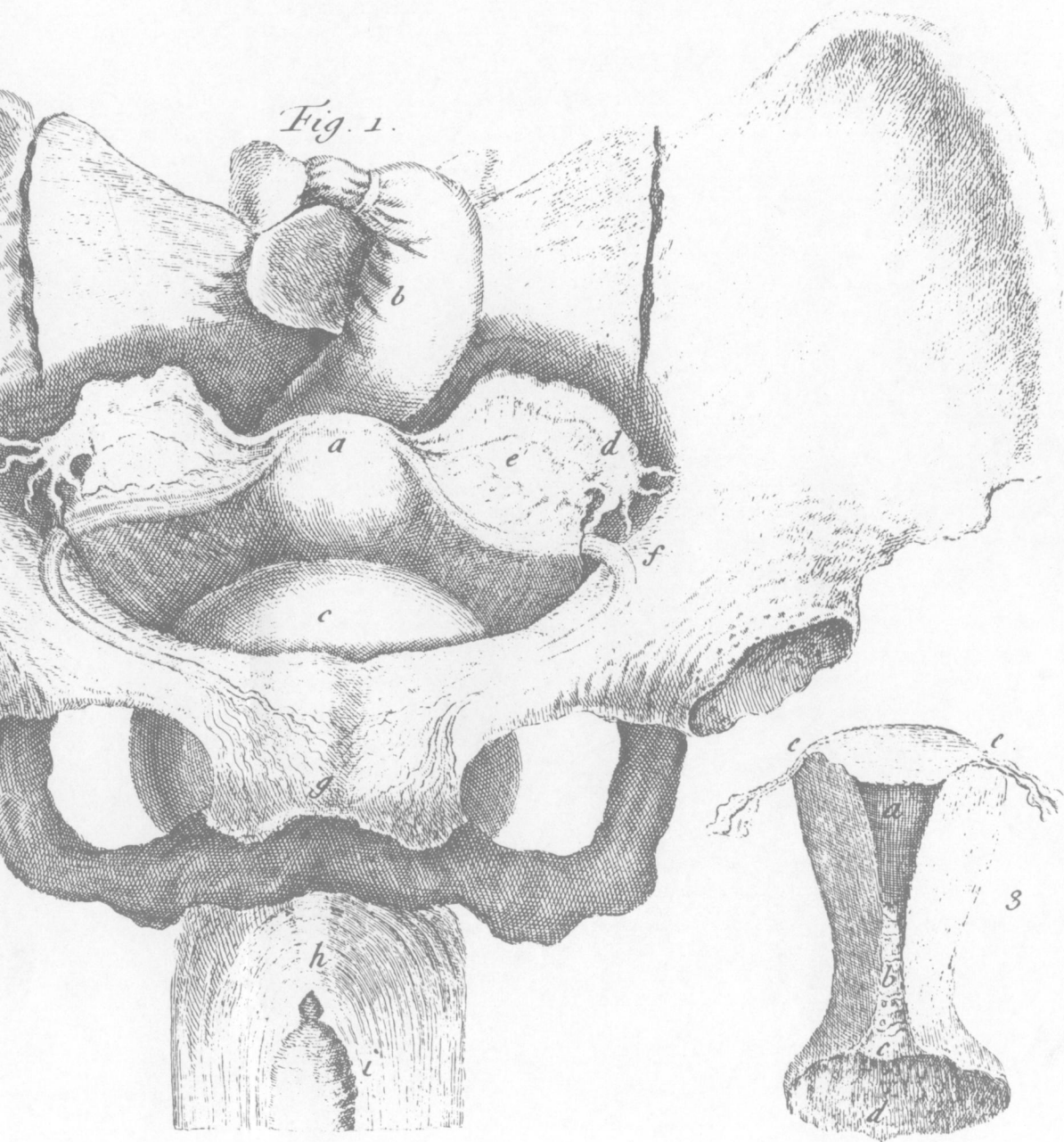
TAB. II.

Fig. 1.

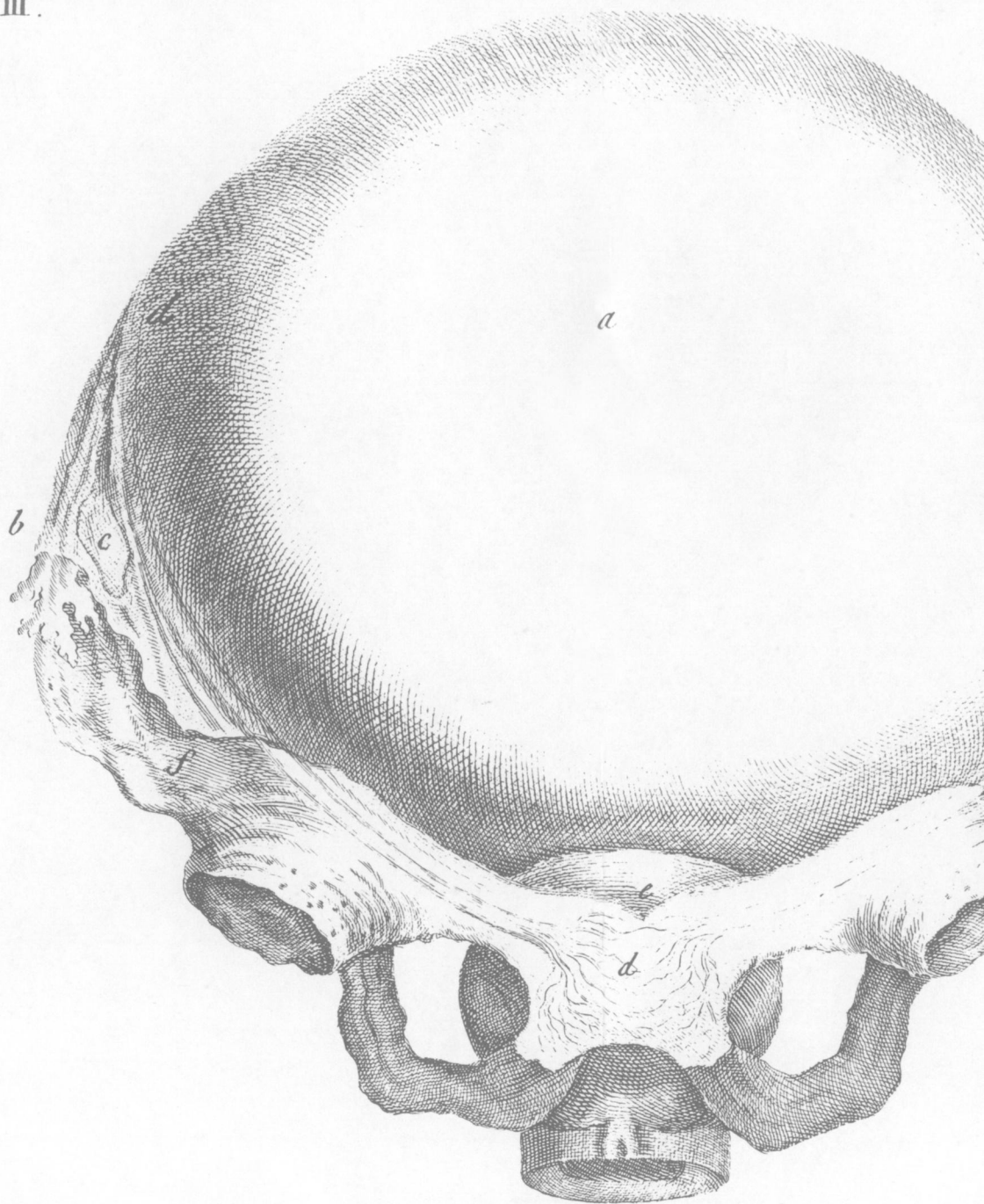


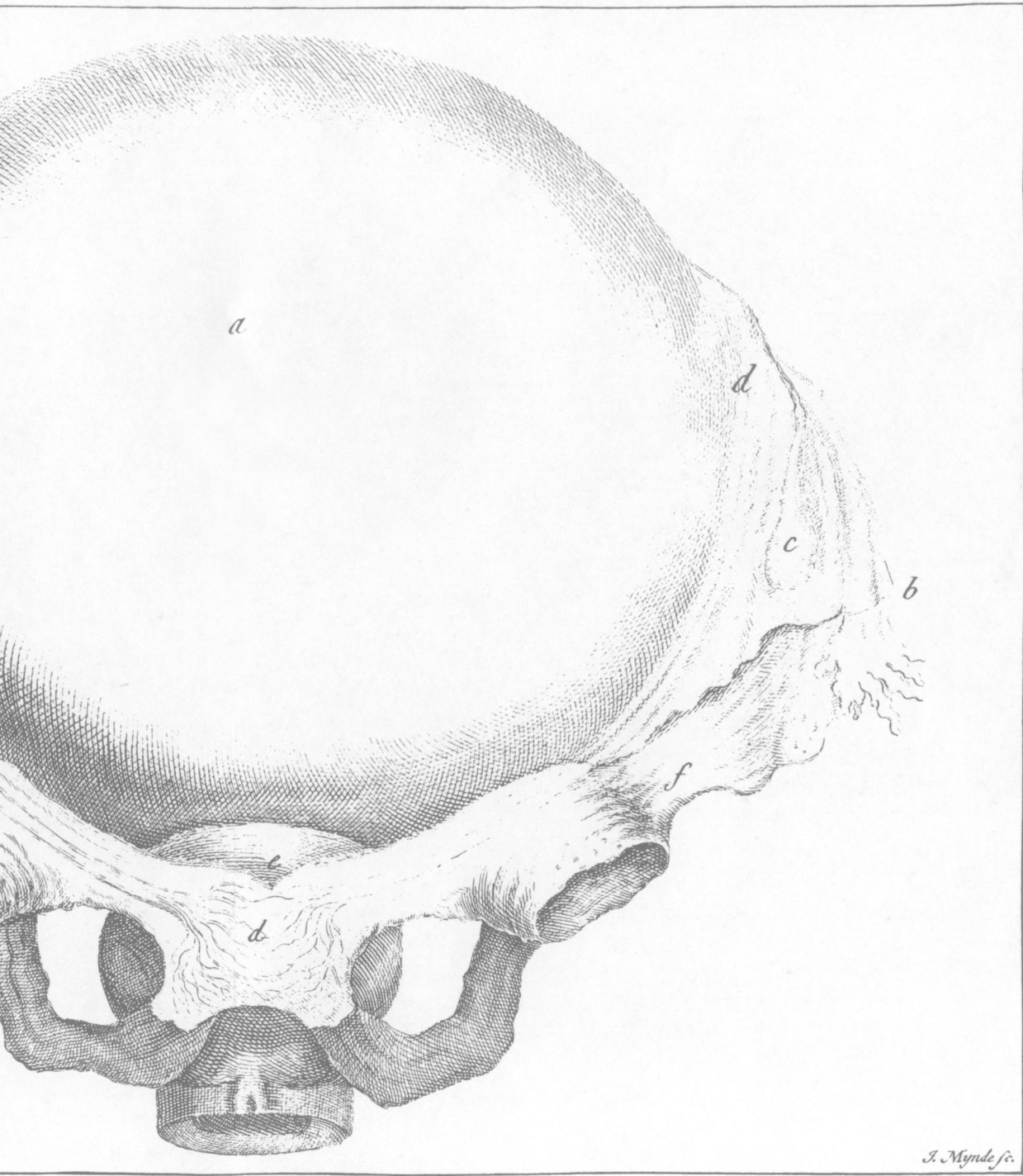
TAB. II.

Fig. 1.



TAB. III.





THE
CROUNIAN Lectures
ON
MUSCULAR MOTION.

LECTURE I.

SECT. I.

Read in January
1743-4.

THE proper Motion of the Muscular Fibres of Animals, and the Manner of its being communicated to, and continued in them, is a Subject so abstruse, that it is with the greatest Diffidence imaginable I have attempted its Explanation. It is the last Subject I would offer at, of all that the boundless Scope of Nature affords us. And, indeed, no other Motive should have engaged me in it, than to comply with the Command of the worthy *President* and Council of the *Royal Society*, for whom I bear the utmost Esteem.

II.

In this Essay I have nothing in my View but the Consideration of a *muscular Fibre*, and that of a *nervous* one, with the Manner of Muscular Motion's being performed; having purposely neglected to touch upon the Nature of Sensation, or indeed any Calculations of the Force or Powers of Muscles; because they are already well treated of by several ingenious Authors; and are capable of being handled upon Rules of some Certainty; being a Part of the Subject very different from what I take to be the Purpose of the *Crownian Lectures*.

III.

Since, then, those worthy Gentlemen have done me the Honour of appointing me to continue these Lectures on *Muscular Motion* for the present Year, according to the Will of the late Lady *Sadler*, I shall endeavour, to the best of my Power, to gratify them; yet confess myself very unequal to the Task; especially, as several of the most learned and ingenious Physicians of all Ages have hitherto undertaken it with so little Success. However, in order to render what I shall advance upon the Subject the more clear and satisfactory to the *Society*, some of whom may not have made this Part of Philosophy their Study, I presume it will not be disagreeable to premise the following brief History of the most remarkable among the Opinions that have gone before us, by way of Introduction; which will also serve to facilitate the Consideration of this Subject, to whosoever shall
be

be appointed hereafter to undertake the same Task, by bringing the several Opinions together in a small Compass before him.

IV.

Most Authors agree, That a Fluid, commonly call'd *Animal Spirits*, flows from the *Brain*, by the *Nerves* to the *Muscles*, in order to move them; but are at a Loss to know how it is performed; and also, by what means those Spirits are sent, so swiftly, into this or that Muscle to be moved.

V.

Some endeavoured to explain it, by supposing certain *Valves* placed in the Cavities of the Nerves, (where they are divided into Branches *, to go to different Muscles) in order to stop the Reflux of the Spirits, and cause them, upon being brought back from one Muscle, to be determin'd to the other, from the Valve.

VI.

Others, not well satisfy'd with this Scheme, imagined a double Tube, passing from one Muscle to the other, so placed, as that the Orifice of one, in its Contraction, (being furnished with a particular Valve) might be opened, and the Spirits immediately flow through it, from the Muscle to be relaxed into that

B 2

to

* *Cartes. lib. de Homine*, and several of his Followers, were for placing Valves only in the Divisions of Nerves; whereas *Regius, Philosoph. Nat. lib. 4. cap. 16.* thought them to exist elsewhere in the Nerves.

to be contracted; whilst, at the same Instant, the Valve of the latter is shut, in order to hinder their Flowing-out again, that the Muscle may be swell'd. By this Swelling the Situation of the Parts being altered, the Valve opens again, (the other Valve being now shut) and the Spirits flow freely back again to the Muscle to be contracted.

VII.

Cartesius's * Opinion was not very different from this: He supposes "Several Openings in each Muscle, through which the Spirits may pass from one into the other; which are so disposed, that, when the Spirits, which come from the Brain towards one Muscle, have a little more Force than those which go towards another, they open all the Orifices through which the Spirits of the other Muscle can pass into this; and, at the same time, shut up all those by which the Spirits of this may pass into the other; whereby all the Spirits, contained before in both Muscles, swiftly pass into one of them, and so swell and contract it, while the other remains relax'd and extended."

VIII.

These Tubes, Valves, and Openings, are merely conjectural; having never been found by any Anatomist, and being only Children of the Imagination of some Philosophers, produced to serve their uncertain Hypotheses. Nor, indeed, would it be a difficult Matter

* *De Passione Anim.* Part I. Artic. II.

Matter to shew, that neither of these Systems can account for Muscular Motion; and that such a Structure would produce Confusion, instead of that most regular and uniform Process we daily see, in every Action of Life, if our intended Brevity would permit it; which must be obvious to every one in the least acquainted with the Structure and Situation of Muscles. Let us, however, consider other more particular Opinions in their Turns.

IX.

The first I shall take notice of is the memorable Doctor *Croune*; whose Care for propagating the Knowledge of this Part of Physiology, is no less laudable than evident, in his Foundation of these Lectures. He shew'd a good Example in his own Attempt towards an Explanation of Muscular Motion, in a Treatise intituled, *De Ratione Motus Musculorum**: Wherein, after a short Recapitulation of some Opinions before him, particularly of those of *Cartesius*,
Regius,

* This Treatise was published at London in 1664. in 4to. and at Amsterdam in 1667, in 12mo. and its being published without his Name, occasion'd a gross Mistake in the Publisher of Dr. Willis's Works at Geneva; who printed it among that Author's Tracts, notwithstanding there is a particular Tract in the very same Volume, known to be Willis's own, intituled, *De Motu Musculari Medico-Physica*. The Editor's Apology for so doing is as follows: ' *Traëtatum de ratione motus musculorum, (etsi authoris anonymi) anatomie cerebri, nervorumque descriptioni ab excellentissimo viro D. Thoma Willis, M. D. celeberrimo, institutæ, (ut alias, tum a materie affinitate, tum ab operis præstantia petitas, missas faciam) quod in prioribus editionibus magno cum doctorum applausu, & sine ulla, quod sciam, clarissimi D. Willis querela, appositus reperiatur.*' See the Geneva Edition in 4to, an. 1680.

Regius, and *Dr. Scarborough*, he endeavours to found his Reasoning upon Mechanical Laws, in accounting for Muscular Motion; and lays it down as a principal Maxim, That the Motion of every Muscle is begun by a certain spirituous Liquor passing from the Nerves; but is accomplished, or finished by two other necessary Causes which succeed it. He despairs that any one can ever arrive at the Knowledge of the Manner in which the Soul acts upon the Body, and therefore avoids troubling himself about it; but produces many Reasons to shew, that whatever it is that gives Motion to the Muscles, must necessarily pass by the Nerves. This leads him to inquire into the Structure of a Nerve; which, he says, "Is composed of a certain medullary Substance full of Juice, with a double Membrane which involves that Substance; and also an infinite Number of little Cords within these Membranes and medullary Substance, extended from their Beginning to the very extreme Capillaments", which are dispersed and inserted into the Parts of the Muscle.

X.

But *Dr. Croune* refers to it himself as his own, in a Paper, p. 25, intitled, *An Hypothesis of the Structure of a Muscle, and the Reason of its Contraction*. [Read in the *Surgeon's Theatre*, anno 1694, 1695]. This (says Professor *Ward*) is the Substance, or Heads only, of the Doctor's Discourses upon that Subject, published by Mr. *Hook*, in his *Philosophical Collections*, Num. 11, Sect. 8. P. 22.; which, being afterwards translated into *Latin*, was inserted in the *Acta Eruditorum*, anno 1682, p. 194. with the Title *De Motu Musculorum*. See that learned Author's *Lives of the Professors* of *Gresham-College*, p. 323.

X.

In speaking of these Spirits, he says, That the alimentary Juices abound with very subtil active Particles; which, by their frequent Circulation with the Blood, are gradually freed from the terrestrial Parts, wherein they were confined. These are in great Plenty in the arterial Blood; which, being carried through the Arteries of the Brain, deposits in its medullary Substance, by a slow Kind of Distillation, a Fluid, which our Author calls a *Mercurial Liquor*, that is (says he) exquisitely impregnated with a *volatile Salt* and *Sulphur*, which flows from thence into all the Nerves of the Body, passing every way through them slowly, and at length falling into the Veins by a gentle Circulation, till they arrive again at the Heart: And that, by these spirituous Liquors, all the Parts of the animal Body grow very turgid, and are kept in continual Agitation, assisted by the Circulation, and the *Calor nativus*. And this Agitation is what he calls the *very Life*.

XI.

And although this Author allows the Nerves to abound thus with this rich *rectify'd Juice*, yet he denies that they are regularly tubular, as Authors affirm, but only as they are defined above; and also that any Kind of Cavity can exist in a Muscle; and, consequently, that there can be no *Inflation* of its Parts: But is of Opinion, that in every Muscle there are three Kinds of Spirits; one peculiar to the *Tendons* and their Fibres, another to the *Muscular Flesh*, and another which comes to the Muscle by the *Nerves*.

XII.

These spirituous Liquors, (says he) together with the Membranes of the Body, are the Instruments of Sensation also. For he concludes, that all the sensible Membranes of every Part of the Body arise from the *Meninges* of the Brain; and that they are all kept in a Kind of Tension, by these spirituous Liquors passing constantly thro' them. In this State of Tension or Tone, he thinks that they may be compared to a Glass, or Bell *, whose Parts have a vibrating Motion communicated all over them, by being touch'd in One Part. Thus, (says he) by the Inter-mediation of the Membrane of the Nerve that belongs to any particular Organ of Sense, or by means of the one common Membrane which involves the whole Body, every Object of Sense is carried, as much as can be, by right Lines, to the Brain; wherein the various and distinct Motions of Objects are perceiv'd by the Soul. Hence this ingenious Author would endeavour to shew how, in a *Paralysis*, Sensation should remain when Motion is lost, and the contrary: For that if that Tone of the Membranes should at any time be totally, or in Part, destroy'd, by either Change of Situation of their Particles, or by the Access of too much Moisture, or any Division of their Continuity

* There seems but little Analogy between such vibrating Bodies and Membranes. It is, indeed, the Property of a Bell or Glass to vibrate and sound, when struck, provided it be pendulous, or otherwise free: But, if any Part be touch'd, its Vibration and Sound are impeded: How much less is a *moist* Membrane, in the Body, capable of Vibration; since it is in close Contact with other Parts every-where?

nuity by an Accident, that then, indeed, that Vibration or Undulation of Particles, which causes Sensation, would be interrupted; like a cracked Bell or Glass, which, instead of its agreeable sharp Sound, exhibits a jarring disagreeable Noise.

XIII.

Our Author defines a Muscle, as consisting of an infinite Number of *tendinous Fibres* like Cords; which are so blended together at the Extremities, as to resemble a thick Cord composed of many others; but that within the Body of the Muscle those Fibres are at some Distance from each other, and the Spaces between them filled up with *Flesh*; which, with Membranes, Blood-vessels, Nerves, and innumerable Lymphæducts, constitutes the intire Muscle. This Flesh, in the Spaces between the Fibres, he says, is nothing else than that Portion of Blood flowing thro' these Interstices; which, being condensed * by the Coldness of the Fibres, is detain'd between them, and constitutes the Muscular Flesh.

XIV.

He has given an ingenious Scheme for explaining the Manner in which a Muscle is moved, after having laid down the above *Preludia*; the Sum of which is, That a certain Power is determined from the Brain,
by

* It is to be fear'd, if Blood could be evafated, the least condensed Particle would be sufficient to form, by degrees, Abscesses, or some other Mischief.

by the Will, with these Animal Spirits, through the Nerve to the Muscle to be moved ; which causes the first Tumescence of the Muscle : And that the Soul has an *Imperium* *, through the whole Mass of Blood also ; as is manifest in the various Passions of Anger, Joy, Love, Bashfulness, &c. whereby she is capable of determining the Blood to any Part in a greater Quantity than ordinary, and, consequently, to the Muscle to be moved : For, says he, it is not absurd to imagine, that the same *Idea*, which excites the Will to move a Muscle, and the Spirits in the Nerve to perform it, in like manner is capable, at the same Instant, of determining Spirits to the Heart, by the Nerve

* It will appear in the next Lecture, that the *Soul* can have no *Imperium* over the Blood, and only presides over the voluntary Actions of the Body ; for the Heart drives the Blood indiscriminately to all Parts of the Body, for its Welfare, by a propelling Force, which is involuntary : Nor can the Motion of the Heart be accelerated immediately by the Will, but only by some particular Act of the Body before ; such as an Increase of Exercise by Running, &c. And as to those Passions of Anger, Bashfulness, Joy, &c. they first occasion quick and irregular Respiration : This causes a quicker Motion of the Heart, which warms and rarefies the Blood more, whereby it is driven with greater Velocity to all Parts, and among them to the Cheeks. Thus Blushing happens, not because the Soul determined more Blood than ordinary to them, but because its *Momentum* is increased involuntarily by the Shock or Surprise previous to it : For the whole Surface of the Body is affected in the same manner, tho' most apparent in the Cheeks. Hence no Increase of Blood can be determined to one Part more than another ; unless some Impediment happens to its free Circulation in one Part, or the Resistance becomes less in another ; which we shall hereafter shew. But besides, one would be apt to think, if the *Soul* had an *Imperium* over the Blood, she might as well prevent the Effects of Poison, or any other Malignity in it, and correct the Mass ; as immediately determine it in a more than ordinary Quantity to any particular Part of the Body.

Nerve which is inserted and dispersed thro' its Auricles, and causing it to propel Blood more copiously to the Muscle.

XV.

The Use he makes of this is, That a third concurring Cause of Motion in a Muscle should be brought in, in order to render it more complete; and that is, A Fermentation produced by the Animal Spirits of the Nerves, and what he calls, the Spirits of the Blood; which he compares to that of any two chymical Liquors mixing together: And that when this Agitation is begun in the Membranes of the Muscles, the Fluids will be driven, by Their *Nifus*, in right Lines towards the Extremities of the Muscle; but that, finding the Spaces much narrower in them than in the Belly of the Muscle, they are driven back to the Middle into the Muscular Flesh, where the Pores are larger, and more lax; which makes the Muscle swell, by the Particles endeavouring to recede from each other, and occupy a larger Space; as, says he, happens in all Fermentations: From hence, as the Spaces are made larger in this Muscle, there is Room made for the Access of more Blood from the Artery in the moving Muscle. Thus Muscular Motion is performed (according to our ingenious Author) by three conjunct Causes; *viz.* *Animal Spirits* flowing to the Muscle, *Arterial Blood* determined in greater Quantity than ordinary, and a *Fermentation* * raised by

* We shall find this learned Author's *Fermentation*, as it serves to account for Muscular Motion, seiz'd on by most of those that followed him, without giving him Thanks for it.

by their Admixture, by which the Muscle. is swell'd and shorten'd.

XVI.

Our Author has not only manifested (in his Treatise) much Learning, but also a penetrating *Genius*, in many curious Remarks and Observations dispersed through the Whole; and merits the Regard of the learned World no less than some Authors we shall mention by-and-by; who, by pluming themselves with *his* Feathers, had monopolized much Esteem and Attention from Mankind, by the Exhibition of this System, with very little Addition; and may indeed be justly said to have led several of them, by his Hints, into their most favourite Notions concerning *Muscular Motion*.

XVII.

Steno. *Steno* *, another ingenious Author, wrote his *Conjectures* on this Subject much about the same Time with Dr. *Croune*; but had a very different Notion from what we have just mention'd concerning the latter; and which, for its Particularity, shall have a Place here; especially as it will appear hereafter, that he laid the Foundation, upon which *Borelli* rais'd his Hypothesis, as to what regards the Structure of a Muscular Fibre; besides what Assistance he has had from Dr. *Croune* on other Accounts.

XVIII.

* *De Musculis & Glandulis Observationum Specimen.*

XVIII.

This Author, after having expatiated a good deal upon the different Structures of the Muscles, and made several learned Observations thereon, makes his general Conclusion to the following Purpose:

1. That Arteries, Veins, Nerves, Fibres, and Membranes are the constituent Parts of a Muscle: And that, though some Authors have pretended to have found Lymphatics, he never could find any.

2. That there is no Muscle whose Fibres do not terminate in a Tendon; which are collected either into firm Tendons at one or both Extremities, or are diffus'd into Membranes, or degenerate into an officious Rigidity.

3. That those very Fibres (which, being closely connected together, compose the Tendon), when join'd more loosely, constitute the Flesh or carnous Substance; and that therefore the Flesh is not a particular *Parenchyma*. In which Sense a Tendon is a continued Body from the Beginning of a Muscle to the End.

4. That there is scarce any Fibre in a Muscle which constitutes a right Line; but every one is divided into three Lines at least, which comprehend two alternate Angles. Nor are these three always right Lines; but often the Flesh, as in the *Sphincters*, and sometimes the Tendons, form curved Lines.

5. These three Lines of every Fibre in the same Muscle, are not always of the same Length; altho' there is scarce any Difference of Extension among them when acting all together: That these Fibres are in the same Plane; and that, in this angular Order, they form *oblique-angular Parallelograms*, or *Rhomboidal Figures*;

gures; whose two opposite Parallels, in the Place where they comprehend acute Angles with the other Parallels, are stretched to the opposite Parts without the Angles. Here he makes a Remark, That in every Tendon, tho' never so slender, there are as many Filaments as there are fleshy Fibres in the Belly of the Muscle; and the interior Filaments are shorter than the exterior.

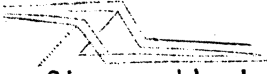

6. His sixth Conclusion is taken up in the Division of a Muscle into Extremities and its Middle, with some Animadversions on that Head.

7. He says also, That a Membrane not only goes round each Muscle with a transverse Direction of its Fibres, but that it also insinuates itself in the same manner between every muscular Fibre.

XIX.

When he comes to speak of the Action of a Muscle, he confesses ingenuously, that he cannot attempt explaining the Cause or Manner in which it is performed; yet makes a Comparison towards an Explanation, which he thinks not improper, but wherein, I must say, I cannot find any Satisfaction. Imagine, says he, a Machine for driving Piles into the Ground drawn up by several Men, each having his particular Cord which is fasten'd to the main Rope: The *Cords* imitate the Tendons; the *Weight* fixed to the Cords, the moveable Part; and the *Men*, the fleshy Fibres: For, says he, as Men (being render'd shorter while they pull their Cords) move the Weight, so the fleshy Fibres, being contracted, by drawing the Tendons, pull the moveable Part. There is no more understood by this Comparison, than that the Contraction
of

of the fleshy Fibres causes the Tendons to come nearer to each other, which every-body has said; but the grand Question is, How they are contracted? And as to this particular Structure of the Fibres, I believe none but the Author himself ever fancied he saw them so. For, supposing this angular Form in every

one  to be the real Structure, the Contraction would reduce it to this Form 

But the Cause and Manner how this is brought about upon this Plan is inexplicable; especially since much Force is required to draw the Weight or moveable Part. But enough of this Author: Let us now proceed to give a short Sketch of the Opinion of a much more famous Author, the great Dr. *Willis*.

XX.

He commends the foregoing Author very much for his ingenious Conjecture about the Structure of the Muscular Fibres; and gives a Detail of what that Author has said concerning them, with an Air of Approbation; but attempts accounting for the Cause and Manner of the Performance of Muscular Motion, of which the following is the Sum: *Willis.*

XXI.

Animal Spirits are carried from the *Encephalon*, by the Nerves, to every Muscle; and are received by the membranous *Fibrillæ*, and by these forwarded into the tendinous Fibres; there to be reserv'd as in a proper Receptacle or Store-house. These Spirits, as they are of a most active and elastic Nature, as often

as it is necessary, expand themselves, and fly swiftly into the fleshy Fibres; and, having made their *Impetus*, recede into the Tendons, by turns. But, while these Animal Spirits pass into the fleshy Fibres, at the proper Instinct for performing the Motion, they meet with very active Particles of another Kind supplied by the Blood, which ferment together; so that, from their Strife and Agitation, the fleshy Fibres, which were before lax and porous, are fill'd up, and are forced into Corrugations; from which the Contraction of the Muscle proceeds. When the Contraction is finish'd, the pure Spirits, which remain, recede, for the most part, into the *tendinous* * *Fibres*, the other Particles remaining among the *Flesh*; the Blood supplying the Expence of these, and the Nerves of the others. And as to the Instinct or Disposition to the Ordination of Motion, our Author thinks that to be produced by *other Spirits*, sent out from the Brain to the Muscles when Motion is requir'd, which, by their various Impulse, ordain those Spirits, already placed in the Tendons, to different Motions either of Expansion or Recess. This is the Scheme for the Performance of Muscular Motion, according to this learned Author; the chief Part of which is the Agency of Fermentation; wherein there appears but very little Difference between this and the Doctrine laid down by Dr. *Croune*. There seems however some Impropriety

* Here are clearly Dr. *Croune's* three Kinds of Spirits; those in the *Muscular Flesh*, those of the *Tendons*, and those sent from the *Brain*; besides the Fermentation they produce by meeting in the Belly of the Muscle.

priety in imagining, that, when fleshy Fibres are fill'd or puffed up by Fermentation, they should be subject to any kind of Corrugation; it being rather an Effect of Emptiness than Repletion in flexible Bodies.

XXII.

This Hypothesis, however ingenious in the Whole, does not seem very satisfactory; and indeed it was soon taken into Consideration by the famous Dr. *Mayow*, who rejects both this and the Opinion of *Steno*; urging many Arguments against the Sufficiency of either in accounting for *muscular Motion*. Let us see how far he excelled them on the same Subject himself.

XXIII.

This ingenious Author * takes notice of *Mayow*. two Sorts of Fibres; viz. *muscular Fibres*, and membranous *Fibrillæ*: The former he describes with *Steno*; being satisfy'd with what that Author has said about them, as to their Structure:—The latter, being the *Fibrillæ*, he says, are a wonderful Series of Fibres parallel to each other, and which intersect the fleshy Fibres in a transverse Direction, yet somewhat obliquely. This Observation he has made upon boil'd muscular Flesh; and says also, That altho' it had been the Opinion before him, that Contraction was performed by the muscular or fleshy Fibres, yet it is his Opinion, that the *Fibrillæ* are principally con-

* *Traëtatus quinque Medico-Physici. Vide De Motu Musculari, cap. 2, 3, 4, &c.*

concerned in that Action : For that, in order to a due Contraction, if it was made in the fleshy Fibres, they must of Necessity be much more shorten'd than the intire Muscle itself; because they are not disposed according to the longitudinal Direction of the Muscle, but are inserted obliquely into the Tendons : And also that the Muscle would swell to an immense Size; which, he says, does not happen upon muscular Motion. Hence he concludes, that the Motion is performed by the membranous *Fibrillæ*; which, being contracted, draw the fleshy Fibres more closely together, and render the whole Muscle shorter and more hard.

XXIV.

It is remarkable, that in *Plate 3. Fig. 2.* of this Author, the Figure he gives to represent the Situation of the fleshy Fibres, and the *Fibrillæ* that intersect them, is copied by Dr. *Stuart, Plate 2. Fig. 2.* with this Difference, that *Mayow* calls the minute intersecting Fibres, membranous *Fibrillæ*; whereas the former calls them nervous *white Fibrillæ* *; and, in his third Figure, supposes each carnosus red Fibre to have a Chain of *Vesicles*, which represent a String of Beads or *Necklace*. Now, as to these *Vesicles*, our Author seems to have given the Hint to some of those

* These are no more than the Fibres of the Membrane that invests the muscular *Fibres* mention'd by *Steno*, and which really exist; for, in tearing asunder, with one's Fingers, the Fibres of a boiled Muscle, they are very apparent; and seem to be what *Bernouilli* imagines to bind his fleshy Fibres at equal Internodes, of which more hereafter, being first thought of by this Author, (*Mayow*) as Agents in muscular Motion.

those that wrote on the same Subject afterwards : For, where he speaks of the Manner of the Circulation of the Blood thro' the Muscle, against some Opinions before him, " that it is extravasated from " the Arteries, and absorbed by the Veins," he says, That the Veins and Arteries meet by the Intermediation of Vesicles, which he calls, *Collectio Vesicularum sanguiferarum* * ; that no such Extravasation can happen, and that this Collection of *Vesicles* constitutes the chief Part of the muscular Flesh ; and also, that their chief Use is, like a Strainer, to separate from the Mass of Blood certain Particles, necessary towards the Contraction of the Muscles. This, if maturely considered, will be found to square pretty much with *Keil* and *Stuart*, as to their *Vesicles* ; as will hereafter appear, when we speak of these several Authors.

XXV.

He also agrees in other respects with some of his Predecessors ; particularly about the Necessity of an Effervescence, being raised in a Muscle, necessary to its Motion ; occasioned by the Admixture of Particles
of

* Which indeed do not exist, but are however first thought of by this learned Author ; who also finds it necessary to bring to his Assistance the *Fermentation* of the most worthy Founder of these Lectures ; yet differs from him as to the Nature of Animal Spirits ; the latter giving them the Name of a *Liquor exquisitely impregnated with a volatile Salt and Oil* ; and the former calling them *nitro-aerial Particles*, which ferment by mixing with the *salino-sulphureous* Particles of the Blood : Both which Terms seem to be the Invention of Dr. Mayow.

of different Natures, according to the Power of the Will; which proceed from the Brain and Mass of Blood. Those from the Brain, he says, are *nitro-aerial* Particles, and the true Animal Spirits; and those from the Blood he calls *salino-sulphureous*; and that the former, being sent by the Nerves, meet the latter in the Muscle wherein they are secreted, as was said before, and make the Emotion and Fermentation, which is the Cause of muscular Motion.

XXVI.

As to his Manner of muscular Motion's being brought about, it seems to be intirely his own Invention: He denies that it can be performed by Inflation, either of the muscular Fibres, or *Fibrillæ*; the latter of which, according to him, are solid Bodies, and can undergo Contraction no other way than by Twisting or *Contortion*; and that those *nitro-aerial* Particles are very fit to affect the *Fibrillæ* in that Manner, To prove this, he brings the following Experiment: Let a small String of a musical Instrument be held between the Fingers of each Hand, at a considerable Distance from each other, over a lighted Candle, so as that it may become sufficiently heated without burning: When throughly hot, it will be perceived to contract with a considerable Force, by twisting itself; and, moved from the Candle, will be easily distended again, by untwisting. Thus, says he, the *nitro-aerial* Particles issuing from the Candle are the Cause of the Contraction of the String; as they are of the *Fibrillæ* being writhed and shortened about the muscular Fibres in the Body; which being by that means drawn closer together, the whole Muscle is shorten'd.

This

This Experiment, he says, is the more to be relied on, because, by Microscopical Observation, he pretends to have found these *Fibrillæ* exactly like a fine String of a musical Instrument. From this System he concludes, that, as some Force is necessary to dis-tend the String to its former Dimensions after Contraction, if no Force is applied, it will always remain contracted ; and that therefore, when there happens a *Paralysis* of a Muscle, its Antagonist is convulsed, or is spasmodically affected. Thus much is sufficient to shew what our Author's Notions were concerning this difficult Subject. The next we shall consider is the famous *Borelli*; a Man famous indeed for his Calculations of the Powers of moving Bodies, but much less so for his Account of the Cause and Manner of the Motion of Muscles. The following is the Substance of his Opinion concerning that Particular.

XXVII.

He supposes *, that, within the Mem- *Borelli.*
brane which invests a Muscle, the *Fasci-*
culi of muscular Fibres have a prismatical § Form ;
which is sometimes triangular, sometimes square, and
sometimes

* Johan. Alph Borelli *De Motu Animalium, Pars prima, c. 2. Prop. 1. & c. 17. Prop. 114, 115, 116. Pars altera, c. 3. Prop. 22, 23, 24, &c.*

§ Our Author thought so, because he made his Observations upon a dry'd Ham ; which, having its Moisture exhaled, and its Fibres being collected, by the Salt used in preserving it, into Bundles, will flake off in Parcels when boiled. But it must be obvious to every one, that Salting, or Boiling, will alter the Contexture of Fibres so minute ; and, consequently, that no great Truth can be drawn from such Observations.

sometimes hexagonal; each of which is composed of many Filaments, or tendinous Fibres, which are parallel to one another in every little Bundle or Fascicule, and adhere together by a tenacious *Gluten*, if they are not continued to the Extremities of Tendons, or Membranes; and sometimes are immediately connected to Bones, or carnous Fibres.

XXVIII.

That besides, these Bundles are every-where invested and bound together by innumerable transverse Fibres *, as it appears in a Muscle boil'd, and immediately dry'd; which nervous Fibres seem to compose certain reticular Membranes, together with the Capillary Vessels § that bring Blood to them, and carry it back again; and that these Fibres are nervous, he conjectures from their being very hard and tough.

XXIX.

His Description of a muscular Fibre, which he has observed after being boil'd, is, that it seems, by the Help of a Microscope, to be a *Cylinder* like the Twig of a Tree, not hollow, as a Reed is, but is observed to be full of a medullary Substance, which ought to be spongy like the Pith of Elder; because every soft Twig, which is fill'd with any adventitious Moisture, grows turgid, and is necessarily porous, since it is
fill'd

* These are no other than the Fibres of the investing Membrane mention'd under *Mayow* in Note (*) *Sett.* 24.

§ This reticular Structure is made use of by Dr. *Stuart* in his Explanation of muscular Motion; which see in his *Turn*.

fill'd with Particles of Water as with Wedges, as it appears in a wet Rope. He seems to be further confirm'd in this Notion, because he observed, in the Fibres of a Piece of *dry'd Ham*, certain sanguineous Particles, or strait and transverse Filaments, dispersed like *Porphyry* or Marble; which, says he, seems not possible to be so, if the internal Substance of the Fibres were not spungy.

XXX.

From his Notion of this spungy Contexture of the internal Substance of a muscular Fibre, he is led further to *imagine*, that it consists of Pores of a rhomboidal Figure, so as to resemble a Chain of *Rhombus's*, which are capable of Contraction like so many Bows, by the Help of the *moving Faculty*; and that each of these *Machinule*, or rhomboidal Pores of the fleshy Fibres, are so minute, that their Length does not exceed the twentieth Part of an Inch. Hence his Definition of a Muscle is, that its Texture is like a reticular Bundle, composed of rhomboidal Chains contiguous to each other.

XXXI.

A Nerve, he says, is a Bundle or Capillament formed of a Number of fibrous Threads, connected together by a membranous Binding; and that every Fibre may be hollow like a Blood-vessel, altho', from the Imperfection of our Sight, they may seem solid: Yet, if it be not impossible, that they may be Tubes, he had rather believe them little Tubes fill'd with a moist spungy Substance analogous to green Elder, or the like ;

like ; because the nervous Fibres are not only soft, flexible, and moist, but also because they admit humid Nourishment, and a Fluid drops from them ; all which Properties require spongy Porosities bedew'd with some Liquor.

XXXII.

As to the Manner and Cause of muscular Motion, he allows, that a spirituous Liquor, which in some Places he calls *Substance*, or *Faculty*, passes by the Nerves from the Brain to the Muscle ; and that some Fluid, proper to the Muscle, meeting it, something like a Fermentation or Ebullition is excited, which causes that sudden Swelling of the Muscle. The Examples he gives to render this familiar to the Reader. are the Spirit of Vitriol poured upon Oil of Tartar, or any acid Spirits mix'd with fix'd Salts. Hence we see from whom this Author has been furnish'd with his Opinions concerning muscular Motion ; *viz.* the *Rhombus's* from *Steno*, with a very little Difference ; and the Fermentation from the memorable *Croune* ; notwithstanding his being frequently quoted as the real Inventer of these Notions.

XXXIII.

Bernouilli. The celebrated *Bernouilli* *, altho' confessedly a Follower of *Borelli* on this Subject, as it appears in his own Words, where he says, " In which (Account of muscular Motion) I shall tread in the Track of the incomparable *Joh. Al-*
" *phonfus*

* *Dissertatio de Motu Musculorum. Vide Proem.*

“ *phonfus Borelli*, embracing his Hypothesis:” Yet blames him for imagining that the *Machinulae* in the muscular Fibres were of a rhomboidal Figure; and will appear to have made no other Alteration, even in what he finds Fault with in that Author’s *Rhombus’s*, than to cut off their lateral Angles; and by that means reduce them to elliptical Forms bound together, at their Extremities, very regularly by transverse Fibres.

XXXIV.

The Account he gives of the Structure of muscular Fibres is the same with that of the foregoing Author, so needs not be repeated here: We shall therefore only give the Reader an Abstract of some Sections of his *Dissertation on muscular Motion*, which regard the Part of this Subject we are at present concerned in.

XXXV.

In his second Section, after he has mention’d *Borelli’s* Inspection of a boil’d Muscle, he says, The Fibres of the little Bundles are collected together by transverse Fibres, which are parallel to each other, and form with the former a reticular Texture; to which he ascribes no other Use, than to confine the moving Fibres, lest, in performing their proper Action, they should be forced too far asunder * from their
natural

* We must here assent to *Bernouilli*, that the membranous Fibres, which not only inclose every Muscle, but proceed to invest every Fibre,

natural Situation. Thus every moving cylindrical Fibre, by the Help of this Ligature, is divided into equal *Internodes*, forming *Vesicles*, which are flaccid when the Muscle is inactive, but when acting, are distended, acquiring an oval Figure like the *Rings* of a *Chain*, which, says our Author, *Borelli* falsely calls *Rhomboidal Machinulae*: And also adds, that these transverse Ligatures are loose enough to admit a free Communication for the moving Matter to fill the *Vesicles*.

XXXVI.

His third Section is chiefly taken up in the Confutation of *Steno's* Opinion, That muscular Motion is perform'd without the Access of any thing whatsoever, but by the sole Disposition in the Fibres to change their Figure, from an oblique-angular Parallelogram into a more strait one; and opposes to it that common physical Axiom, "*Omne quod movetur, movetur ab alio.*" And, in the fourth Section, assents to Dr. *Croune*, with *Mayow*, *Willis*, and *Borelli*, that Motion must be caused by a *Fermentation* raised in the Muscle; believing also with the latter, that the Nerves are a *Congeries* of Tubes fill'd with a spongy Substance, which are always full of a very spirituous Juice, supplied by the Brain, of such a Nature, as
(when

Fibre, serve only to keep them in their natural Situation; but that they divide them thus into Bladders at equal Internodes, we must deny; inasmuch as we have been so happy as to separate distinct muscular Fibres, and demonstrate them before the learned *Royal Society*, and to many Anatomists since these Lectures were read. For their proper Description, see *Lect. 2. Sect. 3, 4, &c.* TAB. I. *Fig. 1. &c.*

(when mix'd with the Blood) to be capable of raising a Fermentation : This is the Animal Spirit. So that, when the Soul performs an Act of Volition, there must of Necessity happen a certain local Agitation of animal Spirits in the Brain, from the great Union between the Soul and Body ; whereby the Beginning of some Nerve receives an Impulse, which is continued to the Juices thro' its whole Length : And so, from an Irritation at the Beginning of the Nerve, the last Drop of the nervous Juice is, by a gentle Vibration, thrown out at the other Extremity, and also from the little Mouths of every other Nerve dispersed through the whole Muscle in the same manner, according to the Power of the Will. And as a Sponge fill'd with Liquor suffers not a Drop to fall out, so, says our Author, altho' those little Mouths of the Nerves (*in the Muscle*) are always open ; yet the Drops of the nervous Juice never fall from them, without an actual Impulse or Concussion ; because the spongy Substance of the Nerves serves them instead of Valves*.

XXXVII.

When therefore, says he in his *fifth* Section, by the Command of the Will, or from Nature's Custom (in involuntary Motion), innumerable Drops are thrown out together from the Orifices of the Nerves, thro' the intire Bulk of the Muscle, which is always thoroughly moistened with Blood ; then these spiritu-
ous

* This is also taken from *Borelli*, where he speaks of a Nerve.

ous Particles or Drops, by striking their sharp *Spiculæ* into the more fine Particles of the Blood, break them, and give the confined condensed Air Room to expand itself, and cause the subsequent Ebullition and Inflation of the Muscle.

XXXVIII.

But, because an Objection might lie against this System, as, How it comes to pass, that the Muscle should so suddenly grow slender, and reassume its former State; since, according to our Author's Doctrine of Fermentation, it should seem, that, after the first Ebullition, the Muscle ought to remain constantly swell'd; he proceeds to remove that Obstacle in his *sixth* Section, by having recourse to the following Hypothesis: Let us suppose, says he, besides the thick Air we breathe, another more subtile Air; which, however elastic, can by no means be perceived, as being capable of penetrating freely all the Pores of the Body. He thinks this Supposition not at all absurd, as believing that there is other Matter of different Degrees of Subtility, between this grosser Air of the *Atmosphere* and the *Materia subtilis*, lest there should be a *Chasm* in any Part of Nature; and thinks it must be elastic, from the same Cause that that of the Atmosphere is; to wit, from the continual Motion of the *ethereal Matter*, which always endeavours to drive the less agitated and gross Particles from each other, and thereby obtain for itself a free Passage.

XXXIX.

XXXIX.

This being pre-supposed, says he, the Particles of the spirituous Juice of the Nerves are so very subtile, delicate, and tender, that their *Spiculae*, which at the most gentle Touch are blunted, are only capable of opening the most minute Pores of the Particles of the Blood, from which immediately that more subtile elastic *Aura*, that was condensed before, rushes forth, and expands itself, thereby swelling the Whole at once; but, because of the exceeding Minuteness of its Particles, it freely breaks out thro' the open Pores of the Muscle, and flies off into the ambient Air. Hence the Muscle must of Necessity grow lax in a Moment after its Intumescence; unless new Drops of the nervous Juice continually fall into it, creating a Succession of Fermentations, and so keep it in a constant State of Inflation*.

XL.

This is the Sum of the Opinion of that great Genius the famous *Bernouilli*, touching the Manner in which muscular Motion is performed: The next is that of one as eminent, the learned *Keill*, but whose Sentiments of the Matter agree well with those before him. He defines a Muscle to be “a Bundle of
“ parallel Plates of fleshy Fibres, which are com-
“ posed of other smaller Fibres, and each smaller
“ Fibre

* We shall find the following Author says no more than *Bernouilli*, explaining it only a different Way.

“ Fibre to be a String of Bladders or Vesicles, into
 “ which, he supposes, the Nerves, Veins, and Arteries to open.

Keill. “ That the Contraction, or Swelling of
 “ the Muscles, is performed by the Blood
 “ and Animal Spirits distending these Vesicles ;”
 but endeavours to prove, by many ingenious Arguments, that neither the Spirits alone, nor the Quantity of both together, distend the Vesicles ; but that both mixing and rarefying * together, cause them to swell : For, “ That the Globules of Blood continually circulating through these Vesicles of the
 “ Fibres, which are, probably, capable of containing
 “ only one Globule at a time, in which Globule (he
 “ supposes a Globule of Air) meet with the Animal
 “ Spirits which drop from the Nerves: That the
 “ Spirits surrounding the Globule of Blood must attract the Particles of it, of which they are composed, more strongly than the others of the Globule of Blood ; and, consequently, their *Nisus*
 “ to one another ceasing, the condens’d Globule of
 “ Air will expand itself with a very considerable
 “ Force ; whereby each Vesicle of the Fibre will be
 “ distended,

* What the foregoing Authors call Fermentation, Effervescence, &c. this Author calls Rarefaction. *Bernouilli* endeavours to explain it by the *Spicule* of the nervous Juice striking against the finer Particles of the Blood ; and this Author, by the Attraction and *Nisus* between the Animal Spirits and the Drop of Blood when they meet in the Vesicle : So that, in the Whole, they may be consider’d to speak the same thing (and even not to differ much from their Predecessors) ; for it is no great Matter whether the Globule of Air is freed from its Confinement, by *Spicule* opening the Pores of the Blood, or by the Attraction of Particles to each other.

“ distended, and, consequently the Fibre shorten’d,
 “ or the whole Muscle will be contracted.

“ But, when the Particles of the Globule of Blood
 “ are mixed with the nervous Fluid, they will both
 “ together inclose the Globule of Air again, and com-
 “ press it into as small a Space as it was in before :
 “ And thus the Contraction of a Muscle must imme-
 “ diately cease, unless fresh Blood and Spirits, suc-
 “ ceeding one another, continue the Swelling of the
 “ Vesicles *.”

XLI.

This System, however ingenious, as it admits of so many bare Suppositions, upon which these Authors found their Arguments, it will be difficult to think it the true Explanation of muscular Motion : But admitting every Supposition to be true, yet the Time that this kind of *Nifus*, *Attraction*, *Rarefaction*, *Fermentation*, &c. must necessarily take up in the Performance, can no way be accountable for the quick Motions performed by the Muscles of the
 Organs

* The only Difference that seems to be between this and the foregoing Author is, that the *Aura*, after being let loose, and swelling the Muscle, flies off into the open Air, according to *Bernouilli*, and the Muscle ceases to swell : Whereas our present Author says, his Globule of Air is again condensed into as small a Space as before, and the Swelling and Contraction of the Muscle ceases : However, their Conclusion is the same for the Continuance of the Motion or Swelling ; this Author requiring fresh Blood and Spirits succeeding one another ; and the foregoing Author the same, in these Words : --- *Musculus iterum detumescat, nisi jugiter novæ instillentur Guttulæ Succi nervosi, quæ novam & novam pariendo Ebullitionem, Musculum in continua Inflatione conservent.*

Organs of Speech, the Twinkling of Eye-lids, or any others that are done as quick as thought, no more than it can be reconciled to the Nature of involuntary Motion, in those Muscles that are not subject to the Impulse of the Will.

XLII.

His Explanation of Rarefaction, admitting we expected no Use of it in muscular Motion, seems to be very particular too; for we can scarce have any other Cause in View for Rarefaction or Condensation, than *Heat* or *Cold*; which are sufficient of themselves to produce those Effects in the most *homogeneous* Fluid, without the Admixture of any other. Whether Rarefaction can be effected by any other Cause in the Body, will be hard to determine, if we do not suppose those Spirits to be an acrimonious Fluid, capable of causing a Commotion with the Globules of Blood in the Vesicles, which would amount to a *Fermentation*; but our Author says all is done without Fermentation, by this methodical *Nisus*, and Attraction of the Particles of the Spirits to each other.

XLIII.

Quincy. I must here insert another very remarkable Notion propagated by *Quincy*, from a Hint of *Bellini*, as it appears in his Explanation of the eighth Aphorism of *Sanctorius's* second Section, where he owns his being led by * *Bellini*, in his
Notions

* *Opuscula de Villo contractili.*

Notions of the Structure and Power of a distractile Fibre. He supposes the Parts of a distractile Fibre to be made up of certain *Machinulæ*, like *Syringes* and their *Embolus*'s, and their Motion to be analogous to that of the Instrument mention'd. " The Observations and Experiments (says he) which have been made of late, but more particularly by Mr. Boyle, about the Spring of the Air, have explained to us the Contrivances and Properties of a *Syringe*; and the Reasons upon which that Phænomenon of the Difficulty of drawing back the *Embolus*, when the Pipe is stopped, depends; and the Necessity of any Liquor's following it, wherein the Pipe is immersed: The Reason of which being well considered, it will be found, that all which is necessary for this Contrivance is, that the *Embolus* be so exactly adapted to the inner Surface of the Barrel, as to prevent any Air passing between them when it is drawn up; and that it matters not what Figure the Barrel is of, so that the *Embolus* is well fitted to it. It easily therefore might be contrived to make a Case of Syringes, wherein every Barrel may also serve as an *Embolus* to its Exterior, which immediately includes it. And, with this View, it is not at all difficult to imagine a continued Series of Particles so put together, that the inner may be moved and drawn upon one another, without suffering the Air immediately to enter into the Interstices made by their Distraction: Whereupon, as soon as that Force which drew them is removed, they will, for the very same Reason as the *Embolus* of a *Syringe*, rush up again into their former Contacts." This is his Notion of the Arrangement

ment of the Particles composing the main Substance of an animal Fibre, and of its Construction.

Now it is no difficult Matter to overturn this System, since there are two principal Objections to be made to it, which prevent the Trouble of any further Consideration. The first is, That this absolutely is not the Structure of a muscular Fibre, as we shall make it appear in the following Lecture: And, secondly, There is a great Absurdity in the Comparison he makes between the Action of a *Syringe* and its *Embolus*, and that of a *flexile* fibrous Thread: For, as it is necessary, in the Action of that Instrument, that its Sides should be inflexible, hard, and able to bear the excessive Force of Suction in the Retraction of the *Embolus*, and the Force of the Air in its Repulsion, with how little Propriety can this minute supple Fibre of a Muscle be said to be capable of a like Action, or such a Wedge-like Construction as this Author thinks applicable to it.

When, in mechanical Reasoning, we find it necessary to illustrate an Opinion by a Comparison, there ought to be a true Similarity of Structure in the Objects whose Actions are to be compared; otherwise it would be altogether as prudent to liken a human Blood-vessel to a Blunderbuss.

XLIV.

Monro. The ingenious Professor * *Monro*, of *Edinburgh*, supposes the nervous Fluid to be
 “ an extreme fluid saponaceous Water, flowing in a
 “ con-

* *Anatomy of human Bones and Nerves*, p. 29. of the latter.

“ constant, equal, *flow Stream*, from the *Encephalon* and *Medulla spinalis*, in each of the proper nervous Fibres, &c. That it is fit for nourishing and restoring the Particles that are constantly carried away from the Solids by the *Vis Vitæ*, Circulation of the Liquors, and necessary Actions of Life; and that the constant Flow of the Liquor of the Nerves into the Cavities of the muscular *Fibrillæ* occasions the natural Contraction of Muscles, by the constant *Nisus* it makes to increase the transverse Diameter, and to shorten the longitudinal Diameter of each Fibre; and that it is only to allow the Mind a Power of pouring a greater Quantity of this Fluid, with greater Velocity, into what muscular Fibres it pleases, to account for the voluntary strong Action of Muscles.”

XLV.

To this Opinion we will here subjoin *Robinson*, that of Dr. *Bryan Robinson* *; who, after taking much Pains to prove, that a Hair or Fibre decreases in Breadth as it increases in Length, and *vice versa*, concludes that, “ if a vibrating Motion be raised in the *Æther* contained in the Fibres of Muscles, the Diameters of all the Fibres will be increased, and their Lengths lessen’d by that Motion: All therefore that is necessary to give Animals a Power of moving their own Bodies, is to give them a Power of raising a vibrating Motion in the *Æther* contained within the Fibres of the Muscles.”

* Dissertation on the *Æther* of Sir *Isaac Newton*.

“ Muscles. And this Power they have by the Medi-
 “ diation of the Nerves, which are solid uniform
 “ Threads, arising from that Part of the Brain to
 “ which the Soul is present, and terminating in
 “ the Muscles: For, a vibrating Motion, rais’d, by
 “ the Power of the Will, in the *Æther* contain’d
 “ in that End of a Nerve which terminates in the
 “ *Sensorium*, or Place in the Brain to which the Soul
 “ is present, will, in an Instant, be propagated to
 “ the Muscles supply’d by that Nerve, and raise a like
 “ vibrating Motion in all its Fibres, from the very
 “ great Communication there is between the Nerves
 “ and the fleshy Fibres of the Muscles.”

XLVI.

At to what Professor *Monro* says of the component Parts of the nervous Fluid, it would be fit for the Purposes he assigns, by a good Analogy drawn from Plants, *viz.* to nourish and supply wasted Particles, as well as to propagate muscular Motion; provided it was of a Consistence subtiler enough to pass thro’ those extremely minute Tubes, and that the Mass of Blood was not the only *Pabulum* design’d by the Creator for affording Nutrition. There is great Need, in whatever Fluid the Nerves contain, of a Capacity of acting with the greatest Celerity imaginable; and one would think a Mixture of a saline and oleaginous Matter not the most fit for such active Performances as the Will sometimes determines, and some of which are as swift as mere Explosions. However this be, our ingenious Author

has not so much made it his Business to account for the Manner in which this Fluid causes the muscular Fibres to increase and swell, in order to the Contraction of the Muscle, as to give the true Description and Situation of the nervous System; than whom none has done it better.

XLVII.

And as to the Opinion of Dr. *Robinson* concerning the *Æther*, it can hardly give Satisfaction: For supposing this *Æther* to be the Cause of muscular Motion, there must be a *Modus Actionis* to produce the necessary Effect; for it is not enough to say a vibrating Motion causes the Muscle to contract, without making some Attempt to shew in what Manner it does so. We can understand as much, by saying at once, The animal Spirits cause the Muscle to move; which was said many Years ago.

But, from a very natural and obvious Argument, one may venture to doubt, whether the *Æther* can have any Share in muscular Motion; for there can be no Motion, whatever, mechanically performed in One Body, without first receiving a certain Propulsion from something else; and the Body making that Propulsion ought to be endow'd with Qualities necessary for such a Resistance, proportioned to the Body acted upon: Now, if the *Æther* (as Philosophers have defin'd it) be a *subtile Matter* pervading all substantial Bodies, of whatsoever Solidity, without Lett or Hindrance, it cannot be said to cause muscular

muscular * Motion, since it can meet nothing to oppose its Passage; and, consequently, can make no Resistance.

XLVIII.

* Whatever Necessity there is for the Existence of the *Æther* in the Oeconomy of the World, we can hardly suppose it either the *Cause* or *Instrument* of muscular Motion; for the *Soul*, or *Mind*, seems to be the very Cause of voluntary Motion: And as to its being instrumental, it will be extremely difficult to reconcile the Qualities of the *Æther* to those of the Parts we shall, in our next Lecture, endeavour to prove are the Instruments of that Motion.

The excessive Distance between the Subtlety of this *Element*, and the Grossness of the *nervous* and *muscular System*, upon which they are, by this Author, supposed to act, will admit of no Proportion: Wherefore, to suppose the Nerves can be impressed by the *Æther*, we must pre-suppose Millions of Gradations of grosser Particles from the extreme Fineness and Subtlety of this, down to the visible Grossness and Solidity of the Organs to be moved, in order, as it were, to hand down the Impulse from the extreme subtle to those extreme gross Particles: All which raises in me so complex an Idea of that Impulse, that I cannot find it compatible with the great Quickness of both the Resolution and Impulse we daily see in the Performance of animal Motions.

There is another Argument, which seems very powerful against the *Æther's* being instrumental in muscular Motion, drawn from some Considerations on the Fire produced in the *electrical Experiments*, now verity'd by Mr. *Watson*, a worthy Member of the *Royal Society*, provided this *electrical Fire* be analogous to the *Æther*; which is, That it is certain, this Fire pervades animal or other Bodies, from my own Experience; as I was one of several Persons thro' whom it pass'd, without having any sensible Effect on me, in its Passage to the Point where it was collected into a Body: And also, because silver *Laminæ* were moved by the excited Tube, even thro' the Sides of a strong Flint-glass Vessel well stopp'd.

It seems, indeed, a very great Care in the All-wise Author of Nature, that this *electrical Fire* should not find Resistance in animal Bodies; because, we see, when all that pass'd from the excited Tube, through several Persons, was collected in one Column at the End of a Gentleman's Finger, it fired rectify'd Spirits of Wine, and Oil of Orange-Peels; and, consequently, might produce as direful Effects as the Fire of *Lightning*, when collected and excited to violent Motion, and is resisted,

XLVIII.

The last Opinion I shall trouble you with *Stuart*. is that of my Predecessor in these Lectures, the late learned Dr. *Stuart*; who (in his Explanation of the Experiment upon the Frog, to which I refer the Reader) concludes, “ That voluntary muscular
 “ Motion is begun by the Impulse of the Mind or
 “ Will on the animal Spirits, thro’ the Nerves into
 “ the Muscles.”

He supposes (with *Keill*) the Structure of a muscular Fibre to be vesicular, with a reticular *Plexus* of Blood-vessels investing each Vesicle: His particular Definition of it is this: “ It is a nervous Fibre, produced from its Entrance into the Muscle, along,
 “ or in the Axis of each carnosus Fibre, in the Form
 “ of a Chain of distensible Vesicles, whose Sides are
 “ cover’d with a Net-work of elastic longitudinal and
 “ transverse Blood-vessels, &c.” Here he makes a Difference between the nervous Fibre in the Form of a Chain of Vesicles, and the carnosus Fibre, along whose Axis it is produced; whereas Dr. *Keill* says, Each Fibre is a String of Vesicles. Our Author endeavours to explain his System by these little longitudinal and transverse Blood-vessels on the Surface of each of these Vesicles, which he calls the reticular *Plexus*. I must confess I do not well comprehend his Meaning; however, the Sum of his Account is as follows:

“ In the utmost State of Extension (of a Muscle),
 “ the longitudinal capillary Blood-vessels on the Sur-
 “ face of each Vesicle in the Fibres must be extended,
 “ and therefore their transverse Diameters must be
 “ lessened;

“ lessened; that is, these Vessels thereby become
 “ straiter, and the Circulation in them therefore
 “ more difficult; and in this State also the transverse
 “ Blood-vessels of each Vesicle will be forced into
 “ serpentine Flexures, which must render the Passage
 “ of the Blood thro’ them still more difficult.

“ If the Mind impels but a little more of the
 “ nervous Fluid than usual thro’ the slender Tubes of
 “ the Nerves into these extended Vesicles, they will
 “ be uniformly dilated.

“ By this Distension of the Vesicles, their *Axes*
 “ being shorten’d, and their Diameters lengthened,
 “ the longitudinal capillary Vessels in their Surface
 “ must be shorten’d, and thereby their Diameters en-
 “ larged, and the serpentine Flexures of the trans-
 “ verse Vessels will be extended; which, in both Kinds,
 “ will lessen the Resistance they gave to the *Transit*
 “ of the Blood; which, by the *Diaστοle* and *Systole*
 “ of the Arteries, is continually urged on to its Pass-
 “ age thro’ them; and, being thus facilitated, every
 “ Globule of Blood in its Progress, by endeavouring
 “ to fly off by the Tangents of these Vessels and Ve-
 “ sicles, tends to expand them more, and thereby
 “ opens the Way for the further and easier Influx of
 “ the nervous Fluid, to which the Blood-vessels con-
 “ tribute, as so many elastic Levers acted upon by
 “ the Blood in its Progress. Thus, by the Assistance
 “ of these three Powers, the nervous Fluid, Blood,
 “ and Blood-vessels, the Progress from Extension to
 “ *Diaστοle* of the Vesicles is made, by which the
 “ Muscle becomes tumid and enlarg’d in Bulk, &c.

“ But, if the Mind desists sending this Recruit, or
 “ suspends it, then these circular arched elastic Vef-
 “ fels,

“ fels, now turgid with elastic Blood, whose *Area's*
 “ have been thus forcibly enlarg'd, endeavour to con-
 “ tract themselves every Way towards the Centres of
 “ their *Area's*, which are the Centres of the Vesi-
 “ cles; and the Mind giving no Resistance, this *Nisus*
 “ takes Place, to the complete Contraction of each
 “ Fibre; by which means the Limb affix'd is brought
 “ into complete Flexion, or Extension, according as
 “ this or the other Antagonist has been acted upon.

“ In this State the whole Muscle becomes shorter
 “ and less in all its Dimensions; harder and paler by
 “ Expulsion of a great Part of its Fluids thro' the
 “ Veins towards the Heart, and thro' the Extremi-
 “ ties of the Nerves into the Tendon and *Peri-*
 “ *osteum.*”

Here he supposes the Spirits to fly off to the Ten-
 dons and *Periosteum*.

XLIX.

None of all these Authors have consider'd the State
 of a Muscle when at Rest; which has contributed not
 a little to assist my Explanation of muscular Motion.
 Our Author has nothing in his View, but the bare
 Progress of the Motion from the utmost Extension to
 the utmost Contraction of a Muscle; and, in the Ex-
 planation, the whole Progress seems intricate and te-
 dious. Again he supposes those longitudinal and trans-
 verse Blood-vessels to be on the Surface of the Vesi-
 cles, which do not appear by any Assistance of the
 Microscope we can apply.

L.

He begins this Explanation with the utmost Extension of a Muscle; and endeavours to prove, that, in its Progress to Contraction, the whole Muscle must grow larger in Bulk every Way, by shortening the *Axes*, and lengthening the Diameters of the Vesicles. This he calls their *Diastole*, which happens from the Mind's impelling more than ordinary of the nervous Fluid; but says, That, when the Will ceases that Recruit, the complete Contraction follows by the *Nisus* of the circular Blood vessels towards the Centre of their Vesicles.

LI.

Now one would be apt to conclude, from this Way of Reasoning, that the Vesicles ought to lengthen again by the Restriction of the circular Blood-vessels; for, as their Diameters were lengthened by the Contraction of the longitudinal ones, so, by the Contraction of their transverse or circular Fibres, the Length of the Vesicle ought to be increas'd again; and, consequently, the Muscle ought to return to its State of Extension.

LII.

Here is one short Particular more, that seems unintelligible, with which we shall close this Introduction: He applies his Experiment on the Frog, to prove, that the complete Contraction of the Muscle is excited from the *Impulse* of the animal Spirits into it; whereas here he says, " If the Mind ceases
 " her Impulse, the *Nisus* of the circular Fibres
 5 " the

“ the Vesicles takes Place, to the complete Contraction of the Muscle.” I submit the Consideration of these different obscure Accounts to Understandings more penetrating than mine; and shall take an Opportunity of humbly offering, before this learned *Society*, in another Reading, my own Attempt towards an Explanation of muscular Motion, pursuant to their Command laid on me for that Purpose.

The End of the First Lecture.

LECTURE II.

Containing the Author's Scheme of MUSCULAR MOTION.

SECT. I.

Read in February,
1743-4.

IN my first Lecture, which is an Introduction to this, I enumerated the chief of the Opinions that have been exhibited concerning muscular Motion, with some short Remarks, which I hope will prove sufficient to shew they could not give the necessary Satisfaction: And indeed I am far from imagining, that I have brought the Subject to a *Ne plus*, or that what I shall advance will prove unexceptionable to every one; therefore if I have been so fortunate as to have hit off but one Step, by which any new Light may arise in this obscure Subject, it is all I can expect: In the Prosecution of which I shall avoid all Suppositions, as much as possible, that cannot be drawn from something experimental; and shall proceed in the most clear Manner I am capable of, in order to entertain you.

II.

There is not the least Motion performed in any Part of an animal Body, which does not depend on a muscular Structure for its Progress, whether in the Fluids or Solids, voluntary or involuntary ; and therefore whatsoever Explanation of muscular Motion is not reconcileable to, and accountable for, every Motion performed in any Part, cannot be the true Explanation.

III.

Of a muscular Fibre.

The most minute muscular Fibre *, that I was able to separate, seems to be tubular, but unequal ; that is, having some Parts of it more protuberant than others, so as to resemble as many Sailors *Hammocks* one after another, and much in the same Proportion in general : We shall call these Bellies or Hammocks, *Cells*, for the better Explanation of the Subject. Now tho' it is a received Opinion, that Fibres are divisible *in infinitum*, that is, that each Fibre is composed of others, and those again of others, and so on ; yet this *muscular Fibre*, as it is a *Tube*,
and

* A muscular Fibre of a middle Size is about equal to the Hair of a Child's Head newly born, at the Strictures or smallest Parts ; the *Cells* being thicker according to the Proportion at TAB. I. *Fig. 1, 2, 3, &c.* Yet some are larger, and some smaller ; the *Cells* however are not to be discerned with a Glass of a less magnifying Power than the Fifth of a double reflecting Microscope.

and serves to perform an Office peculiar to itself, it cannot be divided, without destroying its necessary Form; as a Trumpet, or any other hollow Vessel, cannot be divided or cut into other Trumpets, &c. (let its Size be what it will) and is therefore, properly, an *ultimate Tube* or *Trumpet*, as this tubular Fibre is an *ultimate muscular Fibre*; and this is the Case with the *nervous Tubuli*. Indeed the *Parietes* of every *muscular* and *nervous* Fibre may be composed of Fibres divisible, for what I know, *in infinitum*.

IV.

These Cells are not regularly alike, some appearing three times longer than others, nor at the same Distances from each other; nor do the Fibres themselves seem all of a Size, (*Fig. I. 1, 2, 3, &c.*) and consequently each Fibre contains some more, some less of these Cells.

V.

The Cells communicate with each other by a Passage through the whole Length of the muscular Fibre, till both Extremities terminate in a Tendon or otherwise; which appear'd upon many Experiments both while the Muscle was moist, and after drying a little, having separated them in both Cases; but after being boiled or roasted, every Fibre, I examined, seem'd to have lost its Cells, and become uniform; whence one would be apt to think the Cells had burst by the Rarefaction of the *inflating Matter* * they contain'd,
and

* Sect. X. a little further.

and their Sides become uniform with the Parts that were, before, more slender.

VI.

And as these Cells communicate one with another, it may be reasonable to suppose, that there is no Necessity for any more than one nervous Tube to each muscular Fibre ; so that the Number of nervous Fibres in that Bundle that goes to a Muscle need only to be equal to the Number of muscular Fibres that compose it. From this Structure it is easy to conceive, how the muscular *Cells* are capable of being shorten'd, by their being inflated * and increased in Diameter : And it is to be further observed, that the Bellies or *Cells* of neighbouring Fibres do not lie regularly by the Sides of each other, but promiscuously ; that is, the Cells of some lie close to the slender Parts of others, and sometimes two slender Parts lie together, and sometimes two Cells.

VII.

Of a nervous Fibre.

The smallest nervous Fibre I was able to separate seems to be a Tube ; therefore a Nerve may be defin'd a Bundle of uniform Tubes, whose Sides are parallel

* The Authors, mention'd in my first Lecture, make use of the Word *Inflatio*, and its Verb, to signify a Repletion of the Fibres, or their supposed *Bladders*, *Rhombus's*, &c. with Blood and Spirits, fermented together. On the contrary, I apply it to signify a Blowing up of the muscular *Cells* with an elastic *Aura* only, denying that any Blood or Spirits can get into them. See Sect. X. and XVIII. following.

parallel to, and in Contact with each other, beginning in the *Encephalon* and spinal Marrow, and terminating in Muscles, Membranes, *Cutis*, &c. for the Propagation of Motion and Sensation *.

VIII.

But because they have not been thought tubular by some ingenious Men, it will be necessary to give some Reasons for our thinking them so. If they are not Tubes, but solid Strings, there is no Way of accounting for the Beginning of muscular Motion, but by their Vibration: Now nothing can be said to vibrate that is not elastic, and first in a State of Tension; but, from known Experiments, there is no Elasticity in the Nerves; nor can any Anatomist say he ever found a Nerve in a State of Tension.

IX.

The GREAT CREATOR seems to have wisely avoided any Tension in a Nerve, for several probable

* Altho' I think it not the Business of this Lecture to touch upon Sensation, yet I am induced in this Place to make the following Reflection: If the *Soul* dwells, or exists in every individual solid Part of the Body (which I am inclined to believe, rather than confine her to any one particular Place), sure she may instantly be apprised of every *Contact* producing the different Sensations, that can happen, wheresoever there is a *nervous Expansion*; without our being under a Necessity (by placing her only in the Brain) of bringing to her Assistance an *Undulation* of animal Spirits to and from the Brain; a Vibration of the Nerves; or, with some Authors, contrary Motions of those animal Spirits in the same Tube, serving to Motion and Sensation; all which are productive of many Absurdities, which we have not Room here to enumerate.

ble Reasons: 1. The Origins of the Nerves in the *Encephalon* and spinal Marrow are a mere Pulp, very soft and tender, before they unite to form the Nerve, and very loose in their Contexture; so that a Vellication in any one, produced by Tension, would pull it out by the Roots, and would disorder the Parts of its Insertion too: 2. Supposing the Places of the Origin and Insertion of a Nerve to be firmly fixed, and in no Danger from Vellication, there could still be no Tension in the Nerve, because no Nerve could be brought into right Lines; the very Structure of the Parts, through which they pass, would hinder it; for the Course of the nervous Trunks of the Limbs, &c. being along the Interstices of Muscles, &c. if a Tension was produced in them, the Sides of the Muscles, by which they run, would be preternaturally pressed, and become so many Angles or Centres of that Vellication, to the great Detriment of their several Functions: 3. If a Vellication was produced in the *intercostal Nerve* or *Par vagum*, which communicate with several of the principal Nerves in the Body, would there not be great Confusion brought about, in all the Parts to which such communicating Nerves lead; and would not their proper Actions be much impeded?

From these and such-like Reasonings, we must conclude the nervous Fibres to be Tubes, capable of transmitting something to the Parts into which they are inserted, from the Brain and spinal Marrow.

X.

These nervous Tubes contain a Fluid *, whose Nature and Property is not so much to nourish as to inflate ;

* This Opinion leads me to the following Queries :

1. Is it not well known, that confined Air is capable, by a proper Impulse, of performing more violent and swift Motions, than any *Succus* or *Liquor* that can be conceiv'd ?

2. Are not animal Spirits a *Quid occultum* ?

3. Is not the Blood the sole Mass from which every Liquor of the Body is secreted ? If so, may we not as rationally suppose, that any exalted or refined Liquors, for whatsoever Purposes design'd, may be sent off through exquisitely minute Canals, to answer their several Ends, immediately from the Mass, as to *imagine* such are only secreted in the Brain ? For, by the Assistance of the solar Microscope, such exquisitely minute Canals, as could not be discerned even by the double Microscope in a full View of the Circulation in the Mesentery of a Frog, appear'd to be fill'd with a clear Liquor passing rapidly from the Vessels wherein I saw the Blood circulate, and which seem'd to me some Hundreds of times smaller than those Vessels from which they sprung.

4. Is not the Blood full of Air, and is it not daily supply'd by Inspiration in the Lungs ? If so, why may we not as well suppose, that the Blood carries to the Brain, and there deposits, a sufficient Quantity of an *Aura* to supply the Nerves and muscular Cells, in order to their Motion, as we shall explain it by-and-by, as that animal Spirits are secreted there ? any Liquor, as we have said before, being less likely to serve to swift Motions than Air.

Now till the Negative to these Queries can be proved, I cannot help thinking, that nothing but this *inflating Aura* can enter into the Cavities of the muscular Cells ; and consequently must consider the Brain as destined only for treasuring up this *inflating Aura*, and the nervous Fibres as Pipes to convey it to the muscular Fibres, into whose Cells they alone can open ; that no Nutrition can proceed any other Way than immediately from the Blood-vessels to the Parts that require it ; and that therefore it may, with some Probability, be concluded, that the *Encephalon* and *spinal Marrow*, *Nerves*, and *muscular Fibres*, are a Set of mechanical Organs, exempt from any other Office, than to cause Motion and Sensation by *Inflation* only, so that every Muscle that moves may justly be said to be blown up into Motion.

inflate; and consequently whenever the Nerves are impress'd by the Soul, there is an immediate *Inflation* of all the Cells, in the Fibres of that Muscle which is to perform a voluntary Motion.

XI.

And these muscular Cells, together with the nervous Tube that opens into each muscular Fibre, are constantly full of this *inflating Matter* to a certain Degree; that is, fill'd to a *Medium* between their utmost Compression or Emptiness, and their utmost Capacity of Repletion. By this means, the muscular Fibres, when at Rest, are in a *Medium* between Distension and Contraction; but are distensible to near a Third longer, and contractible to near a Third shorter, than when in a State of Rest; the former, by the *Retraction* of Part of the *inflating Matter* back into the Nerves; and the latter, by its *Impulsion* or Inflation into the *Cells* from the Nerves.

XII.

There is no Necessity for imagining, with some Authors, that the Soul makes her Impulse in the Head rather than any other Part, in order to impel from thence the inflating Matter of the Nerves to this or that Muscle: Because, by supposing the Nerves always thus full, the smallest Impulse on the Part of a Nerve leading to this or that Muscle will be sufficient to perform what is necessary; whereas, if we confine the Power of the Will to the Brain, may there not be Danger of Irregularities like Explosions, from thence into the different Divisions of a Nerve, and

so of causing confused Motions in several Parts at a time, like an Epilepsy? Or if an Impulse be made on the Trunk of a Nerve, the Divisions ought all to be subject to the Effect of that Impulse. It will therefore be better for our Purpose to think the *Mind* makes her Impulse where she pleases, and causes that Part of a Nerve only that leads to the particular Muscle to be moved.

XIII.

This seems to be corroborated greatly by the Motions we see in Insects after being cut to Pieces, as Worms, Flies, &c. and in more perfect Animals, as Poultry, Frogs, &c. which move, and shew Signs of Pain, a considerable time after their Heads are cut off; which could not happen, if the Impulse was only made in the Brain. We can carry this Argument yet further, even to human Nature, if what *Diemerbroeck** relates be true: He says he saw a Man executed at *Leyden*, who, after his Head was struck off, rose upon his Feet, and stood for a little Time. And Dr. *Stuart's* Experiment upon the Frog (which is, after the Head is cut off, and the Limbs hanging loose, to compress the spinal Marrow with the End of a Probe made flat, whereby the Limbs are immediately contracted, and with some Violence) shews, that if the Impulse was made in the Brain, the Motion would be confused and general; since all the lower Parts were moved by the
single

* *Anat. corp. hum.* lib. viii. cap. i. de nerv.

single Impulse upon the spinal Marrow of the Frog.

XIV.

Another Reason for supposing the Soul capable of chusing any Part upon which her Impulse may be made, is, that if it was made in the Brain alone, there might be some Impediment or Interruption to her Intention, produced in the *Ganglions* of the Nerves; which, some Authors think, do the Office of so many Brains, but which, more probably, serve as so many *Fulcra* or *Stays* to keep the Nerves firm, and to favour their further Directions to the different Parts of the Body.

XV.

Of Interstitial Air.

The Air-Pump shews us, that, in all flexible Bodies, such as Flesh, small Animals, and the like, there is a sufficient Quantity of Air, lodg'd in the Interstices between the muscular Fibres and the Blood-vessels, &c. to resist the Pressure of the ambient Air; which Pressure being taken off in the Air-Pump, this interstitial Air will expand itself, and swell the Flesh, Animal, &c. to an incredible Size. This may be considered as a general *Equilibrium* kept up between the ambient Air, and that in an animal Body, for the Safety and Preservation of the Animal: And these Air Globules, which we shall throughout this Essay call *interstitial Air*, are constantly in a middle State between their utmost *Contraction* or *Condensation*,

tion, and their utmost elastic *Expansion*, except chang'd into either State by some adventitious Cause.

XVI.

Of the Circulation of the Blood in the minute Vessels.

The Blood appears, by the Microscope, to flow from Arteries into Veins immediately *, Which is easily seen in the Webs of Frogs, Tails of Fishes, *Mytuli*, and the like; and, I doubt not, would appear so in Muscles, if they were thin enough to become transparent for Viewing with Glasses. Therefore the Arteries and Veins may be considered as continued Tubes, terminating in nothing; but as the Arteries arise immediately from the Heart, so they run to the Extremities of the Lungs and Body, ramifying and decreasing in Diameter, till they become invisible to the naked Eye, and gradually become Veins, which unite into Trunks, increasing in Diameter till they arrive at, and open into, the Heart again. So that Nutrition and the Secretions are carried on by minute Twigs, from these continued *capillary Canals* † sent off to the Glands, and to the Parts to be nourished.

XVII.

* Without the Intervention of any Vesicles, such as *Mayow* suggested. See TAB I. Fig. 3.

† Where the Arteries degenerate into Veins.

XVII.

And it further appears, by microscopical Observations, that these capillary Canals run parallel to, and by the Sides of, the muscular Fibres in general, or to Fibres of whatsoever Nature, where these capillary Canals exist, This seems a very wise Contrivance in every Degree; for if their longitudinal Direction was cross the other Fibres, the Circulation could not be so smoothly nor securely carried on; and therefore would be liable to great Impediments, from a transverse Pressure of the muscular Fibres upon them; whereas, in this parallel Direction, they are secured from any Impediment, but what proceeds from the Pressure of the Sides of the muscular Cells upon their Sides, in the Performance of muscular Motion: We are here to take notice, that the muscular Fibres receive Twigs from the Arteries to nourish them, and from the Veins to carry back the *Residuum* into the parallel Canals, as we have hinted before.

XVIII.

Hence we must conclude, that no *Vessel*, of any kind whatsoever, opens into the Cavities of the *Cells* of the muscular Fibres, but Nerves.

XIX.

Of the Equilibration and Motion of Muscles.

From what we have premised, let us endeavour to shew how muscular Motion is performed, and
how

how the several Principles just laid down are applicable to it.

XX.

The Force of the *inflating Matter* contained in the *Cells*, is only equal to the Force of the *interstitial Air*, while the Muscle is at Rest. This may be called the peculiar *Æquilibration* of a Muscle in itself; but, by the Impulse of the Will on the Nerve, an additional *Inflation* is made to the *Cells*, and then their Force becomes superior to the *interstitial Air* Globules; and again becomes equal when that Impulse ceases, and the Muscle is at Rest. But if, upon the Cessation of that Impulse in one Muscle, there is an Impulse made on the Antagonist at the same time, in order to move it, then the Force of this *interstitial Air* in the ceasing Muscle, exceeds that of the *inflating Matter* in the *Cells*, compressing their Sides, whereby they are lengthened beyond their Tone of Rest; as we shall more fully explain it, when we speak of the *Æquilibration* between antagonistic Muscles.

XXI.

From this *Inflation*, which is perform'd as quick as Thought, the *Cells* instantly increase in Diameter, and grow shorter, compress the venal Canals, and obstruct them. Hence the Blood stops, and the Arteries, by Propulsion from the Heart, increase in
their

their Diameters, while the Veins are squeezed quite empty, and the whole Muscle is shortened, and its Action performed.

XXII.

The Degree of Contraction in a Muscle is always as the Force necessary to perform such or such an Action ; and this is determined by the Degree of the *Inflation* of the *Cells* ; that is, if the Force required be but inconsiderable, then the Impulse of the Mind will be but inconsiderable, and consequently the *Cells* will have but an inconsiderable *Inflation* ; therefore the Pressure of the *Cells* on the minute Veins will be in Proportion : So that of the arterial Blood, tho' it flows always in the same Quantity into the Muscle ; yet, because the Pressure of the *Cells* on the Veins is but small, a proportional Part will go on, and return by the Veins ; and therefore the Repletion of the Muscle, and its Contraction, can be but inconsiderable : Whereas, when a violent Motion is to be performed, then the Degree of *Inflation* of the *Cells* will be very great, the Blood totally stopped in the Veins, the Arteries increased in Diameter, and the Muscle shortened even to its ultimate State of Contraction, if requisite.

XXIII.

While the Circulation is thus hindered in the acting Muscle, there can be no Disorder occasioned, either in the Oeconomy of the Circulation in other Parts of the Body, nor in the particular Constitution of the Muscle itself. The former Case is certain from our daily Experience of Amputations ; wherein,

tho' a Limb be cut off, and the Space in it immediately wanting, and although the same Quantity of Blood, supply'd by Digestion every Day, is carried into the Vessels, yet their Distensibility is such, that the only Change they can suffer is further Repletion. And as to the Muscle itself, if, during a violent Action, there should happen any Danger of Injury, it would be perceived immediately by the Mind, and remedied by ceasing her Impulse on the Nerve and *Cells*, and thereby granting a free Circulation instantly.

XXIV.

As to the *Æquilibration* between two antagonistic Muscles, Dr. *Stuart*, in his Lectures *, thinks, that
 “ As each Antagonist has its distinct Nerve or Nerves
 “ without Communication, and the antagonist Mus-
 “ cles communicate one with another by one com-
 “ mon Trunk of an Artery, and one common Trunk
 “ of a Vein; they are like two antagonist Scales *in*
 “ *Æquilibrio*, over which the Mind has a distinct
 “ Power, by distinct Nerves, for determining the
 “ animal Spirits, and thereby the Blood, to either
 “ Side at Pleasure, without affecting the other : And
 “ concludes from thence †, that if what is taken
 “ from one be added to the other, the *Momentum*
 “ of the Motion will be doubled.”

XXV.

* Lect. III. pag. xliii. Sect. 9.

† Sect. 17. pag. xlv.

XXV.

Now there does not seem to be Occasion for taking away any Blood from one Muscle to be determined to the other; nor has the Doctor explain'd how it may be brought about by the Mind; nor, indeed, can I conceive it possible to hinder the Motion of the Blood in the arterial Trunk, leading to one Muscle, while it is sent to the other; except we could suppose the Mind capable of making a Ligature, or other Stricture, on the Ramification leading to it, leaving the other open at the same time. But no Nerve can have such a Power from the Mind to act upon the main Trunk of an Artery; and therefore the *Effect* of the Mind's Impulse upon the Nerve can only be produced, as I have said, on the most minute venal Canals; where they are capable of being press'd by the Bellies or *Cells* of the muscular Fibres that lie by their Sides, and where alone the mechanic Structure of the Parts admits of it: Besides, the arterial Pulsation must of Necessity go on, to carry Blood to every Part of the Body, being propell'd by the same constant Force always, in healthy Bodies. Hence the Convenience of this our System of muscular Motion is apparent, since it is carried on at the same time that the Heart and Arteries do their Offices without Interruption to either.

XXVI.

Again, if it was absolutely necessary to muscular Motion, that Blood should be taken from an Antagonist, in order to be sent to the acting Muscle to break the *Æquilibrium*, some Muscles, that serve

to involuntary Motion, could not have any Motion at all, having no Antagonist. Therefore, in general, Motion must be caried on more simply, and in the Manner explain'd above.

XXVII.

Yet an *Equilibrium* between a Muscle and its Antagonist is absolutely necessary; but it is only so in order to preserve the Equipoize between them, while both are in a State of Rest. Now there are two Sorts of *Equilibriums* proper to Muscles, the one which is peculiar to each Muscle in itself, explained before, and the other that which is between two Antagonists. Let us see how the latter is broke, in order to Motion.

XXVIII.

We are to consider two Antagonists exactly equilibrated, before any Action is begun in either. The Mind, now resolving to act with one Muscle, makes an Impulse upon the Nerve leading to it. The *Cells* in that Muscle are instantly inflated beyond their Tone of Rest, to the Degree necessary for the particular Action intended: The Blood is stopp'd, as mentioned before, in the little *venal parallel Canals*; and the Muscle is contracted beyond its Tone of Rest. And at the same Instant that the Mind impels the *inflating Matter* into the *Cells* of the Muscle in Motion, she remits to determine any to the Antagonist, which causes a *Retraction* of it into the Nerves: By this means the interstitial Air, in this, exerts its elastic Force, compresses the Sides of the *Cells*,
whereby

whereby they are reduced to oblong Forms, and the whole Muscle is drawn beyond its Tone of Rest.

XXIX.

It is thus alone the *Equilibrium* is altered between two Antagonists in an Instant, without a Necessity of taking one Drop of Blood from the one to add to the other: And it is even so far from it, that, during all this Action, the Quantity of Blood in both Muscles, while one is contracted, and the other dilated, is nearly equal; for altho' the Blood is stopped in the acting Muscle, by the Mechanism above explain'd, and the Veins are all compressed, so as to contain none during a violent Contraction; yet the Arteries may be said to contain a double Quantity, propell'd into them by the constant Pulse, as they are elastic, while the Circulation is carried on pretty equally in the Antagonist; and consequently both Arteries and Veins in this can contain no more than the very Arteries in that: Therefore a Muscle is neither larger nor less, in general, by Contraction or Extension, than when in a State of Rest, the Proportion being constantly kept up; that is, when shorter, a little thicker; when longer, a little more slender.

XXX.

Our Explanation of the *Equilibrium* between the interstitial Air, and the muscular Cells, will enable us to attempt accounting for the swiftest gentle muscular Motions that can be perform'd; such as are necessary in an *Allegro* Part on an Instrument of Music.

Muscle. Thus: The Mind intends moving a Finger to perform a swift Shake; the first Motion is a Pressure of the Finger upon the String, by the Contraction of the *Flexor* of that Finger: The successive Motion then will be only a Remission of that Pressure, without any Necessity for a Reaction in the antagonist Muscle, because the Motion required is but inconsiderable: And this Pressure and Remission, by being nimbly repeated, will become a kind of alternate *Tremor* of the Finger upon the String; because, after the first Inflation of the muscular Cells, which causes the Contraction of the Finger, the instant Remission of the Inflation becomes a kind of Retraction of it, as I have said before: Then the interstitial Air follows it with an elastic Expansion beyond its Tone of Rest, and compresses the Cells; then a new Inflation of the Cells succeeds; and, in fine, an Action and Reaction between the interstitial Air and Cells is carried on as long as the Shake is required to continue: This amounts to an alternate *Systole* and *Diastole* between them, like two Springs acting by alternate Repulsion.

XXXI.

Of involuntary Motion.

The Performance of the common Actions of Life depending upon the voluntary Motion of the Muscles alone, Authors have almost neglected to give any Explanation of involuntary Motion; and therefore have chiefly attended to the former: Whereas the latter as well deserves the Attention of the Learned,

and depends as much upon the same mechanical Principles and Structure, differing only in this, that voluntary Motion is urged by the Will, and the other is carried on without her Impulse.

XXXII.

It appears, by what we have already said, that the Disposition of muscular Fibres to contract depends on an additional Inflation of their Cells, but that this cannot be done without an impelling Power upon the Nerve to cause it. Now, in the Performance of voluntary Motion, the Will must be supposed to make this Impulse; but we must endeavour to find some other impelling Cause of Motion in the Muscles of involuntary Motion to set them to Work: For the mechanical Structure of all Muscles is alike.

We will produce two Examples; the *Heart*, and *intestinal Canal*.

XXXIII.

By a very natural Analogy between Vegetables and Animals, I am apt to believe, the Parts of the Animal are perfectly formed in the *Ovum*, before its Egress from the *Ovarium*, only wanting *Explication* and *Expansion*; but that these two Effects cannot be produced, till after it has changed its Place, and is deposited in such a Receptacle as may favour the Propagation of these Effects. Just so it is by the Seeds of Vegetables.

This being the Case, in order to come at our Purpose concerning involuntary Motion, we must now consider the *Fœtus* in the *Uterus*, tho' very
small,

small, as having all its Parts complete, but motionless, or in a State of Rest.

XXXIV.

Now the Heart is the first Part that can have any Motion at all; and, being in a State of Rest, must be supposed in a *Medium* between its Dilatation and Contraction. The first Motion in the Heart then will be a compulsory Motion, which is its *Diaſtole*; and the first Motion performed by itself will be its reſtitutive Motion or *Syſtole*. Till this is done, there probably can be no Accretion of Parts, becauſe nothing can be propell'd to the Extremities but by the Contraction of the Heart. And this is much earlier brought about than many Authors have imagined, and in the Manner following.

XXXV.

It is certain, that Fluids paſs from the Mother to the Child very early, by the Veins of the *Funis umbilicalis*, and at length arrive at the *Vena cava*.

The Auricles and Ventricles are now in a State of Rest; but the Fluids falling into the right Auricle, with a Gravity and Force it was not liable to before, it is fill'd and dilated beyond its former Tone; whereby the muſcular Cells are laterally compreſſed, and become longer by the diametrical Preſſure, and the interſtitial Air is alſo compreſſed into narrower Limits than before, and the whole Auricle is upon the Stretch: Thus its *Diaſtole* is compulsory.

XXXVI.

XXXVI.

Now this sudden Repletion, at the same time that it dilates the Auricle, makes such an Impulse upon its nervous System, that an Inflation succeeds in the Cells, whereby they increase in Diameter (the interstitial Air now concurring by its *Nisus* to restore itself); and these two Powers together, which, in performing voluntary Motions, are Antagonists to each other, are now forced to become joint Antagonists to the dilating Force of the intruding Fluid from the *Vena cava*, whereby the Auricle is contracted, and the Blood driven into the neighbouring Ventricle. Thus is the Motion propagated from Auricle to Ventricle, and from the Ventricles to the Arteries thro' the whole Body, which is carried on during Life.

XXXVII.

And as to the Intestines, as there can be no peristaltic Motion, till Deglutition is first performed, it is carried on by the same Mechanism: For, when the first Food is swallowed, being driven into the *Oesophagus*, it forces it open, and dilates the circular muscular Fibres beyond their Tone of Rest, compressing both the interstitial Air, and the Cells of the Fibres; which, restoring themselves gradually, again contract themselves successively downwards, till the Food is convey'd to the Stomach, and thence to the Intestines: And this is also carried on till Death, when once begun. I shall only trouble you with one short Section more, which is:

XXXVIII.

Of depraved Motions.

Palsies, Cramps, and Epilepsies, may be accounted for by this System.

May not the muscular Cells become rigid and hard, and not be capable of being dilated to the Degree necessary to carry on the Action and Reaction between them and the interstitial Air, in an equal manner; and therefore produce such irregular Attempts to Motion, as would amount to a paralytic *Tremor*? Frequent Drinking spirituous Liquors will render the Cells of the muscular Fibres rigid, and cause the same Effects; and in Fevers, with what is called a *Subsultus Tendinum*, a common Symptom arises, which is an imperfect Attempt to pull the Bed-cloaths, attended with a *Tremor*. and proceeds from the same Cause; for the violent Heat of the *Fever* has render'd all the Fibres and their Cells rigid, and, therefore, incapable of due Inflation; for that Motion is not made in the Tendon which we feel, but is produced by the irregular Twitchings of the muscular Fibres of that Tendon.

XXXIX.

Or may not these Cells be too lax and weak, and so lose much of their Elasticity, and yield to the Entrance of too great a Quantity of the *inflating Matter* of the Nerves, whereby the interstitial Air may be constantly compressed, and the peculiar *Equilibrium* deprav'd, so as to produce
Spasms,

Spasms, if partial; if total, an Epilepsy? Painful Cramps are occasioned by the Inflation of some of the muscular Fibres, while others are not affected in the same Muscle; and an unequal *Drag* or Contraction is painful, when a total one is more tolerable.

XL.

And as to the Decay of a Limb, it does not seem to me to happen from the Want of a nervous Juice, by way of Nourishment, as has been the common Opinion; but because, whether they be Muscles of voluntary or involuntary Motion, the *inflating Matter* not being able to reach the *Cells*, from an Obstruction in the Roots or any other Parts of the Nerves, so as to fill them up to an *Equilibrium* with the *interstitial Air*, this Air will expand itself beyond its *Medium*, and compress the little Twigs of the *parallel arterial Canals*, that go off to nourish the *Cells* of the muscular Fibres, and lie constantly upon them, and so stop their Nutrition from the Blood; while the *parallel Canals* themselves, being too considerable to be affected by the Pressure of the interstitial Air, continue on their Stream: Thus a Decay of the Limb, and Loss of Motion, is effected, while there is a Circulation continued thro' the Body of every Muscle in the Limb.

XLI.

The Hearts of certain Animals, taken out of the Body, will continue to move a considerable Time, because the Action and Re-action cannot cease at

once between the *muscular Cells* and the interstitial Air, no more than a pendulous Body can cease at once, after having been swung beyond its Point of Rest. The Reason is, that as long as the Heart remains warm, the elastic Force of the interstitial Air, and that of the inflated *Cells*, will have the same alternate Effect upon each other, till the external Cold, and Want of the gradual Supply of the inflating Matter, cause the Action and Re-action to become unequal, and so by degrees fix both: But, when the Motion ceases, it may be again excited for a little time by Pricking. This seems to make a new Impulse on the Matter yet remaining in the muscular Cells, which, acting by their Expansion, will compress the interstitial Air, and receive a Repulse from it for a few times faintly: But this Experiment will not answer, when the Heart is quite cold; but then, if warm Water be pour'd on it, there will be Motion again excited. This happens, because the interstitial Air, before condensed by the Cold, is now instantly rarefied and expanded, and therefore presses the *muscular Cells*; which also being warmed, the remaining inflating Matter will exert itself in its turn, and so continue an alternate Motion for a few times, till the Heart grows cold again. But this Experiment will not often answer; because, altho' the same interstitial Air remains, it is a Doubt whether the Matter of the *Cells* does not exhaust by degrees; in which Case there can be no more Re-action. I have two or three times observ'd, when the Skin of an Ox has been taken off, the muscular Fibres continued to move in Spasms, and ceased at Intervals; then re-assumed their Motion, going on thus till the whole Surface

Surface grew cold, and the inflating Matter of the Cells, for want of a Supply, was quite overcome by the Pressure of its Antagonist, the interstitial Air.

XLII.

There might be many more Observations made upon this Plan, with regard to the Diseases *commonly* called *nervous* ; but as these Lectures were confined to *Physiology* alone, we shall make no Excursion from the Design of the Founder ; and shall be extremely happy, if this most learned *Society* shall approve of this Essay I have now made, in Obedience to their Commands.

The End of the Second Lecture.

LECTURE III.

SECT. I.

Read in October,
1745.

IN performing the Lectures of last Year, besides laying open the Opinions of the most remarkable Authors who have endeavour'd to account for muscular Motion, I have given my own Essay towards its Explanation, which will appear to differ from every Opinion before it. And as I have there produced every thing I could say upon the Subject, touching the *Cause* and *Manner* of a Muscle's being moved, I must confine this Lecture to the Description of certain particular Organs, which, tho' not *commonly* thought so, I shall endeavour to prove to be Muscles: And these are, 1. The *Uterus* itself; 2. The *Fallopian Tubes*; and, 3. The Parts commonly called *Ligamenta rotunda*.

II.

Of the Uterus.

Whoever considers the Offices and Use of the *Uterus*, will hardly hesitate to pronounce it a *Muscle*

cle with *me*. Besides which, the very Structure of its Substance, from many Observations, prove it sufficiently, having discerned its interlaced muscular Fibres, as plainly as those of any other Muscle in the Body: However, its Definition and Use, as we shall now mention them, will serve further to illustrate and confirm our Assertion.

III.

The *Uterus* is an Organ destined, by the Wise AUTHOR of Nature, not only to receive, cherish, and increase the *Ovum*, which contains the *Fœtus*, till it arrives at due Maturity, but also to promote its *Expulsion*, when the Time of Gestation is fulfilled.

IV.

In a *virgin* or *empty* State, it is very small, as it appears at TAB. II. *Fig. 2.*; and being laid open, its Substance and Cavity are no more considerable than *Fig. 3.* represents; yet, in proportion to its Size, its *Parietes* are thicker and more compact, than at any time during its Gestation, whatsoever may vulgarly be thought of it by those who have only read of, and not observed it. This Substance, then, consists of fleshy Fibres and Blood-vessels, both Arteries and Veins; and is cloathed internally by a Membrane, whose whole Surface is set thick with *valvulous Holes*, and externally by the *Peritonæum*: These, no doubt, serve to strengthen its Substance, and hinder its muscular Fibres from being driven too far asunder, by the Distension or Enlargement of the Blood-vessels
(which

(which are very great and numerous thro' its whole Substance), while it is distending gradually, by the Increase of the lymphatic Fluid *, and Growth of the *Fœtus, Placenta, &c.* in it.

V.

In this virgin or empty State, the muscular Part is so squeezed and compressed together, that the Arteries and Veins are quite closed up, and utterly incapable of receiving a Drop of Blood during that State; except some few small Vessels, which only serve for the Continuation of Nutrition: But as soon as the *Ovum* is lodged in the *Uterus*, and begins to increase in Bulk by the Intrusion of the *Liquor Amnii*, it forces the *Uterus* to distend by degrees, till it arrives at the Bulk we see in the latter Months of Pregnancy. By this gradual Distension, the muscular Fibres are forced further asunder, and consequently the Blood-vessels are gradually freed from the Pressure, till at length they increase to their full Dimensions.

VI.

All this time the muscular Part, being compell'd to dilate, can perform no Function proper to a Muscle, until the *Cervix Uteri* is so shortened, as to become thinner than the rest of the *Uterus*; which does not happen till about the Completion of the
ninth

* *Liquor Amnii.* The Manner of the Secretion of this Fluid, which is much controverted, shall be soon accounted for in a Treatise on the *Nutrition of the Fœtus*, which shall be published in *Some Essays on the Diseases of Women.*

ninth Month (a little sooner, or a little later). Now a Word or two of the *Cervix* here, since we are obliged to mention it, will render our Explanation more clear, and will also shew the infinite Wisdom of the *Great CREATOR* in the Formation of this Organ, for the Purposes it is design'd for.

VII.

The *Cervix* of the *Uterus* is a compact Part, narrower than the Body, and about an Inch long (more or less), as at TAB. II. *Fig. 3.* It has two Orifices proper to it while in this State; the one called the *internal*, which opens into the Cavity of the *Uterus*; and the external Orifice, commonly called the *Os Tinæ*, which opens into the *Vagina*. Its Substance is very hard and solid, and it has a very small Passage from the one Orifice to the other, having on its Surface many Glands, which secrete a dense glutinous Substance, and many *Striæ*, to which this *Gluten* adheres; so careful is Nature to keep the *Uterus* close, in order to prevent the Ingress of even the Air.

VIII.

Now this *Cervix* is made thus long and compact, that its Resistance to the intruding Waters of the *Amnium** should be greater than that of the *Parietes* of the *Uterus*, while it is dilating: This gives Time enough and Room for the *Fætus* to grow to Perfection; and near the Time in which this is brought about, then this, which was before a *Cervix* with an Orifice at each End, is now become so much

L

shortened,

* Ἀμνίον, ἢ τὸ. The Name of one of the Membranes that contain the Child, &c.

shortened, as to acquire a greater Thinness than the *Parietes* of the *Uterus*, and consequently to bring both Orifices into one.

IX.

By this time the *Fætus* being come to Perfection, and the Resistance being less at this Orifice than at the other Parts: The *Uterus* now begins to act in its muscular Capacity, beginning by degrees to contract itself alternately, till the Waters and *Fætus* are determined downwards to the Orifice; which, the more it dilates, the more Power the *Uterus* still acquires, by its natural Disposition to contract; until the Muscles of the *Abdomen* are at length drawn into Consent, and the *Conatus*, or Pains, as Women call them, which begin by the involuntary Motion of the *Uterus*, are assisted by the voluntary Contraction of the abdominal and other Muscles towards the Extrusion of what it contains*.

X.

Nor does the *Uterus* rest, after it is rid of every thing, but still continues alternately to contract; until, in some Days sooner or later, it has squeezed out the Fluids from the Blood-vessels, called *Lochia*, compressed them close, and at length acquir'd its former Size and Compactness, or very near it. This is what

* This regards the natural Delivery of a Woman in due time. As to what relates to Abortions at different Times, it is a Subject reserved for another Place.

what causes those Pains, which are commonly called After-Pains.

XI.

Thus is this wonderful *Phænomenon* brought about by the muscular Structure and Mechanism of the *Uterus*; and it may securely be affirmed, that if *it* was not a very Muscle, this Effect could not come to pass, no more than the Blood could be driven from the Ventricles of the *Heart*, if it were not a *Muscle*, or the Urine from the Bladder (without a muscular Coat, and a *Detrusor* Muscle), which are forced to distend by the Intrusion of Urine from the Ureters, till, by its Repletion, the Resistance becomes less at the Orifice than in the *Detrusor*. This is more fully explained in my Description of the Bladder; which see.

XII.

Of the Fallopian Tubes.

These Organs were known to, and well described by, *Hierophilus* and *Rossus Ephesus*, as the late learned Dr. *Douglass* has very justly observed; altho' they are called by *Fallopian's* Name by some not well versed in the History of Anatomy. They are soft pliable Bodies, and are properly enough called Tubes or Trumpets, because they arise small on each Side from the Angles of the *Uterus*, and run larger by degrees, till

L 2

they

they approach the Extremity, and growing again a little more narrow, terminate in ragged *Fimbriae*.

XIII.

The Cavity of each is also so small at their Origin in the Angles of the Womb, that a small Hog's Bristle can hardly be introduced; but it enlarges gradually, till, at the other Extremity, it is capable of admitting the End of a Goose-Quill.

XIV.

These Tubes are in a strait Direction for a little Way from the *Uterus*; but as they enlarge, they grow into vermicular Curves or Flexures, terminating downwards, and a little backward, with their Mouths opening upon the *Ovaria*, altho' not at all attached to them; and are sustained and strengthened by their Situation in the Duplicatures of the *Peritonæum* on each Side, which serves to keep them in their curved State (as the Mesentery sustains the Guts) during the unimpregnated State of the *Uterus*: And these Duplicatures (which also strengthen, and in some measure cloathe, the *Ligamenta rotunda*, and which we shall speak to presently) are what are commonly called the *Alæ Vespertilionis*.

XV.

These Tubes are made up of muscular Fibres, which are partly longitudinal, and partly are situated obliquely, and somewhat circular; from which Structure they have a Motion which may be called a compound Motion, and which amounts to what we
count

count the vermicular Motion in the Guts; but this Motion is not begun, till there is a Necessity for it; which is as soon as an *Ovum* is impregnated.

XVI.

At the Instant that this Impregnation happens, the Orifice of the *Fallopian* Tube clasps itself close upon the Part of the *Ovarium* next to it, by contracting; and receives into it the *Ovum*; which, as soon as it has enter'd, those oblique circular Fibres, or, as we may term the Extremity, the *Sphincter* of the Tube, incloses and pushes it farther in towards the *Uterus*, which is by degrees forwarded by the peristaltic Motion of the Tube, till at length it is push'd into its Receptacle the *Uterus*, in the Manner explained in my last Lecture, where I endeavoured to account for involuntary Motion: And when the *Ovum* is thus settled, then the Cause of this Motion ceasing, the Tube is at Rest; and in proportion as the *Uterus* grows more tumid afterwards, both Tubes lose their vermicular Flexures, and at last grow quite strait and pendulous, as at TAB. III. *bb*, by the general Distension of the *Peritonæum*: But when the *Uterus* is emptied, and again is contracted to its former Dimensions, then the Duplication of the *Peritonæum* is contracted in proportion, and these Tubes are consequently restored to their former vermicular Flexures, and therefore rendered capable of receiving an impregnated *Ovum*, as before.

XVII.

From hence it is easy to conclude, that what has been thought, by many old Authors, and indeed by
some

some Moderns, concerning Superfetation (any considerable Time after the *Uterus* has received one (or more) impregnated *Ovum*) is altogether groundless: For, when the *Tubes* are grown flaccid, after having conveyed the *Ovum* to its Receptacle, and lost their vermicular Flexures, they can no more embrace the *Ovaria* during that Pregnancy; and also because the *Ovarium* on each Side is driven by the Distension of the *Uterus* to a greater Distance (out of its former Situation) from the *Vagina*, and consequently out of the Reach of Impregnation.

XVIII.

Therefore, whensoever it happens that two *Fætus's* are brought forth at different Times, they both come within the common stated Time of Gestation; that is within nine Months, or thereabout, from the *Coit* that produced the Fecundation: In which Case, tho' one may be perfect, and come at the full Time, the other is imperfect, and sometimes wasted, and comes before the due Time, being both begotten at the same Instant, or within a very little Time of one another. But because one shall have more Nutrition determined to it, the other less, the latter, which is always situated nearest the Orifice, will of Necessity suffer Abortion. Thus, different Emissions of Children happen, not because they are begotten at different Times, but because, Nutrition being unequally distributed, the defrauded *Fætus* is extruded by the other, who often keeps his Place till he arrives at due Perfection.

XIX.

XIX.

Before we quit this Part of our Subject, it will not be unseasonable to mention a Case here, which was in some measure, objected to what I had laid down against a Possibility of Superfetation, when I read this Lecture.

A Gentlewoman in *Charles-Town* in *South Carolina*, about the Year 1714, was brought to Bed of Twins, one immediately after the other, in the same Labour. The one proved to be a *Negro* Child, and the other a white one; which very much surprised those that attended about her. So flagrant a Testimony of her Infidelity to her Husband, made her confess before them, that a *Negro* Servant, immediately after her Husband had left her one Morning, came to her; but she pleaded, as an Excuse, that he threatened to kill her, if she did not comply with his Desire; and that accordingly she was forced to admit him into Bed.

XX.

Now, in order to remove this Objection, it must be observed, that what I have asserted is, that when the *Fallopian* Tubes are grown flaccid, and have lost their vermicular Flexures, and the *Ovaria* are driven to a greater Distance from the *Vagina* by the Enlargement of the *Uterus*, that then they are out of the Reach of Impregnation.

Whereas, in the Case before us, there could be no such Change brought about in the *Uterus*; for, altho' one Tube had received an impregnated *Ovum* by the *Coit* of the Husband, and convey'd it to the
Uterus,

Uterus, whereby it may have lost its Flexures, yet the other Tube had not; nor could the *Uterus* be enlarged by the one in so short a time; for it appears the *Negro* cohabited with her immediately after her Husband; so that the *Ovum* impregnated by him was from the other *Ovarium* thro' its neighbouring *Tube*; which might have happened in a second *Coit* with her Husband, as well as with the *Negro*.

From this Structure and Office in these *Tubes*, we may venture to be of Opinion, that they are truly *Muscles*.

XXI.

Of the Ligamenta rotunda.

There have been various Conjectures concerning these slender Bodies amongst Authors; but the greater Part accounted them as Ligaments.

Spigelius, and after him *Diemerbroeck*, had a Notion, that they were *Vasa deferentia*, which they thought carried seminal Matter from the *Ovarium* to the *Clitoris* in Females: But this cannot be the Case; first, because they have no Cavity, that I could find, and are therefore impervious to any Matter: Again, their Situation would not admit of it, supposing they were tubular, because they arise from the Angles of the *Uterus* a little below, and forward of the Ligaments that suspend the *Ovaria*, as at TAB. II. Fig. 1. (*f*); and, passing along thro' the Duplicature of the *Peritoneum* on each Side, rise over the Edges of the *Os Pubis* nearly in a Line above the Fore Parts of the *Acetabula*; and then
running

running thro' the Rings in the *Peritonæum*, and Tendons of the oblique Muscles, &c. turn downwards and forwards, towards each other, on the *Ossa Pubis*, till they are lost in the Fat of the *Mons Veneris*, and sometimes in the Groins; and consequently could not serve to any such Use, having no Communication with either *Ovarium* or *Clitoris*.

XXII.

The celebrated *Winslow* thinks them vascular Cords, arising from the Communication of the spermatic and hypogastric Vessels; and says, they ought to be esteemed as a particular Continuation of the Spermatics; and that he suspects they furnish the Matter which is secreted from the *Lacunæ*. Now these Cords are made up of muscular Fibres alone; for, by the most strict Examination I could make, the Fibres appear to me fleshy, and have a longitudinal Direction from one End to the other; and as to their being vascular, it is impossible, from their Situation, they should be so, because they have not the least Communication with these Blood-vessels he mentions, and have only minute Twigs, as every other Muscle has, for their Nourishment: And as to the *Lacunæ*, which are Glands on the Surface of the *Vagina* in several Parts, they are remote enough from any Communication with the Fibres of these muscular Cords, where they are lost in the Fat of the *Groin*, and *Mons Veneris*; and therefore must be designed for some other Use.

XXIII.

From what I have said of these Cords, I must concur in the Opinion *Vesalius* had of them, concerning their being *Muscles*, who is quoted by *Santorini* on that account; and these, with our celebrated Anatomist, Doctor *Nichols*, are the only Authors that I know of, that have mentioned them as Muscles; yet none, I believe, have ascribed the same Use to them that I think they are employed in; and that only respects the distended *Uterus*, as follows:

XXIV.

While the *Uterus* is in its contracted State, these *muscular Cords* are also in a State of Rest, forming the curved Direction we have mentioned, as at TAB. II. (f); and as the *Uterus* grows larger by its Pregnancy, they are pull'd upward and outward over the *Ossa Iliæ*, being more and more distended, in proportion with the *Uterus*, till they form nearly right Lines from their Origin to their Insertion, and are in many Women in the last Month 15 or 16 Inches long, more or less (See TAB. 3. *d d.*). Whereas, when they are in their State of Rest, they seldom exceed from 7 to 9 Inches. From hence it may be rationally concluded, that when Delivery is over, they assist the *Uterus*, by their equally contracting on each Side, the more regularly to contract itself, because many Evils might be produced by an unequal Contraction of it; but, as they are Part of its Diseases, they can have no Place in this Lecture. And as the muscular Cords can in no wise be said to suspend the *Uterus*, we cannot consent at all to call them *Ligaments*;

ments; nor can we conceive any Use of them while the *Uterus* is unimpregnated at any time. Therefore we must think they are *Muscles*, reserved for the Purpose just mentioned; and neither *Vasa deferentia*, Blood-vessels of any kind, nor Ligaments.

XXV.

Thus I have finished the Task, which the worthy President and Council of this learned *Society* were pleased to charge me with: I return them my Thanks for the Honour they have done me; and make no Doubt but, whosoever shall be appointed to succeed me in these Lectures, will add considerably to whatever I have been able to advance upon these Subjects.

The End of the Third Lecture.

TABLE I.

Fig. 1. 1, 2, 3, 4, shew the Forms of several muscular Fibres, considerably magnify'd by the double Microscope, where they appear to differ in Size, as well as in the Number and Distance of their *Cells*, as it is mentioned in their Description before.

Fig. 2. is a View of several muscular Fibres, with those minute Blood-vessels which I have called the *Parallel* or *Capillary Canals* (see *Lect. II. Sect. XVI. and XVII.*) lying in their parallel Directions, in order to answer the Ends of Nature; which are explain'd in the Course of that Lecture.

Fig. 3. is a Representation of the Circulation of the Blood in a little Piece of the *Mytulus*, not exceeding a Quarter of an Inch every way in its natural Dimensions; wherein it appears, that those minute Vessels are in a Direction parallel to other Fibres of whatsoever Nature.

Fig. 4. shews Part of a *Capillary Canal*, with Part of a *Muscular Fibre* on each Side; to demonstrate how the minute Twigs are sent off from the Canal to the muscular Fibres to nourish them, as is hinted in the last Section above-mentioned. This is view'd by the greatest Magnifier of the double reflecting Microscope.

TABLE II.

Fig. 1. is a View of the *Pelvis*, with the internal feminine Parts of Generation *in Situ*.

a, the Body of the *Uterus*.

b, the *Rectum*, turned over the upper *Vertebra* of the *Os sacrum*.

c, the Bladder.

d, the *Fallopian Tube*.

e, the *Ovarium*.

f, the *slender muscular Cord*, commonly called *Ligamentum rotundum*, rising from the Angle of the *Uterus* on each Side, and ending by several *Fimbriae* at *g* in the Fat of the *Mons Veneris*.

h, the *Meatus urinaris*.

i, the Orifice of the *Vagina* deprived of the Integuments.

Fig. 2. is a View of the Shape of an unimpregnated *Uterus*, all the Appendices being cut off.

a, the Body of the *Uterus*.

b, the *Cervix*.

c, Part of the *Vagina*.

Fig. 3. shews one Half of the same *Uterus*, the other being cut off laterally and longitudinally, whereby its Cavity (*a*), the inner Surface of its *Cervix* (*b*), one Lip of its *Os Tincæ* (*c*), and Part of the inner Surface of the *Vagina* (*d*), come into View.

e, the small Passage from the Angle of the *Uterus* into the *Fallopian Tubes*.

TABLE III.

Shews a View of a pregnant *Uterus* of seven Months.

a, the Body of the *Uterus*.

bb, the *Fallopian Tubes* relaxed and pendulous.

cc, the *Ovaria* also pendulous.

dd, the *Muscular Cord*, called *Ligamentum rotundum*, upon the Stretch.

e, the Bladder.

F, F, the *Ossa innominata*.

F I N I S.